The Journal of HEREDITY

COMPLEX GLADIOLUS HYBRID
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Population Trends Revealed by the 1941 Census

Social and Economic Factors in Birth Limitation

Chromosomes With Two Spindle Attachments

Mutations Induced by Ultra-Violet Radiation

Blood-Antigens in a Dove Species Hybrid

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An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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COMING

MICROMANIPULATED CHROMOSOMES

What happens to a chromosome when you put your finger on one end and pull the other end? Does it break, stretch like putty or like rubber? In the bands or between them?

CUCUMBERS

Can you tell a tetraploid cucumber when you see one? What happens to the cucumber's Public Enemy No. 1 when winter rolls around, and what can genetics do to stop its summerly ravages?

MICE, ETC.

Personality and pelage differences both with a genetic basis. Tailless rodents and deaf cats — but no farmer's wife.

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HYBRIDS BETWEEN GLADIOLUS OF VARIED CHROMOSOME CONSTITUTION

Frontispiece

The genus *Gladiolus* contains species and varieties differing greatly in chromosome number. The basic haploid chromosome number is 15, and many 30-chromosome diploids are known. Most of the commercial varieties of gladiolus are tetraploids with 60 chromosomes. This composite photograph shows species and hybrids with the chromosome number of the parent forms in parenthesis. *A*—*G. tristis* v. *concolor* (30); *B*—*G. tristis* (30) × *G. hirsutus* (30); *C*—*G. tristis* (30) × *G. watsonius* (30); *D*—[*G. callistus* (30) × *G. undulatus* (30)] × *G. blandus* (30); *E*—*G. tristis* (30) × *G. communis* (138±); *F*—[*G. cuspidatus* (30) × *G. tristis* (30)] × [*G. blandus* (30)) × *G. angustus* (30)]; *G*—[*G. callistus* (30) × *G. undulatus* (30)] × [*G. tristis* (30) × (*G. tristis* (30) × *G. hirsutus* (30)]; *H*—Professor Donders (60) × *G. tristis* (30); *I*—Joost v.d. Vondel (60) × *G. hirsutus* (30); *J*—Professor Donders (60) × *G. hirsutus* (30); *K*—Miss Bloomington (60) × *G. pappei* (30); *L*—Miss Bloomington (60) × *G. angustus* (30); *M*—Professor Donders (60) × *G. communis* (138±); *N*—*G. byzantinus* (90); *O*—Professor Donders (60) × *G. byzantinus* (90); *P*—Edith Mason (60) × *G. cuspidatus* (30); *Q*—Nymph (45) × Miss Bloomington (60); *R*—Dillenberg (60) × *G. communis* (138±).

CHROMOSOME NUMBER AND HYBRIDIZATION IN GLADIOLUS*

RONALD BAMFORD

IN a previous paper[2] a list of the chromosome numbers of many species and varieties of Gladiolus was presented and the earlier works on this subject reviewed. At that time particular emphasis was placed on the heteroploid nature of the genus and since then other reports[23,33] have confirmed these results. When the many historical records of the development of this group,[6,7,12,13,17,26,34] particularly in relation to the development of the summer-flowering types, are compared to such chromosome lists it appears that species and varieties with many different chromosome numbers[28] have been involved. This has again been emphasized in some recent works on hybridization[5,14,15,19,20,21,29] concerning the South African species. The presence of triploid ($3n=45$) and pentaploid types ($5n=75$) in the chromosome lists and the infrequent reports of sterility[18] clearly indicated that at least diploid-tetraploid and tetraploid-hexaploid crosses have been made. It has been known for over a century[12] that the South African species could be intercrossed but these are all diploids.

For the past six years our attention has been devoted not only to checking many of the reports indicated above but we have extended our crosses to the widest possible extremes in so far as chromosome number was concerned. Although the study is not complete, many interesting hybrids have been obtained and it seemed wise to summarize at this point. This report presents the results thus far and extends a previous summary.[3]

Materials and Methods

The seeds and corms were secured from a variety of sources. In addition to those mentioned previously,[2] Mr. W. M. James of Santa Barbara, California, has generously provided some other species, and even some of his own hybrids, which were used in this study.

The majority of the crosses were made in the greenhouse between January and May. The flowers or buds were emasculated in the early morning or on the previous afternoon and the anthers were placed in glass vials and stored in a cool place. Preliminary experiments showed that fresh pollen was best and after two days it was generally discarded. Pfeiffer[25] has recently shown that the viability of Gladiolus pollen decreases with age. Bagging was resorted to only when pollinations were made outside during the summer.

The seeds were collected as they matured and, after a summer storage period, planted the next fall. Seedling counts were taken at intervals throughout the winter and spring months. A successful hybridization was arbitrarily considered to have been made when the seedlings appeared. This was arrived at because in many cases the plants died during the first year. On the other hand, many groups of seeds, which appeared to be good, did not germinate and it is possible with better cultural conditions the results might have been altered to some extent.

During the past six years over twenty-five thousand pollinations have been made involving about four thousand different crosses. The majority involved diploid species because these are very abundant and flower abundantly during the winter.

Chromosome Number

Since the publication of the last list certain acquisitions have been made and the chromosome number of these is reported below:

*Scientific Paper No. A5. Contribution No. 1772 of the Maryland Agricultural Experiment Station (Department of Botany).

TABLE I.
Chromosome Numbers of Gladiolus Species.

NAME	*n*	2*n*
G. communis L. variety	90	180
G. ———————— var. Golden Orange	45	90
G. illyricus Koch		90
G. watsonius Thunb.		30
G. maculatus Sweet		30
G. watermeyeri L. Bolus		30
G. martleyi L. Bolus		30
G. namaquensis Ker. Gawl.		30

It is apparent that our previous report[2] of the heteroploid nature of the genus, is extended. The form of *G. communis* has the highest number thus far reported for this genus.

Hybridization

The results of the extensive series of pollinations resulted in nearly sixteen hundred successful hybrids, many of which were reciprocals. The comparative success in relation to chromosome number appears in Figure 1.

The problem of interspecific hybridization generally centers around two points: (1) Whether or not the cross can be made and (2) whether the resultant hybrids are fertile or sterile. Both have some relation to chromosome number. In Gladiolus it seems certain (Figure 1) that, except under wide differences, the range of possibilities for hybridization is great, although it is evident that the chances of successful hybridization diminish as the chromosome numbers of the species or varieties become farther apart. Sharp[31] points out what we have observed, that "as a general rule, one may expect the difficulty of obtaining a hybrid to increase with numerical and qualitative dissimilarities in the chromosomal complements of the parental types."

It appears then, as though the general report from many sources, as expressed by Emsweller *et al*[8] is true, namely that the "original species have been combined and hybrids have been crossed and recrossed until the resulting multiple hybrids possess characters derived from many species." The reported origin of the horticultural type as a cross between *G. psittacinus* and *G. cardinalis* or *G. oppositiflorus* represents a hexaploid-diploid cross. We have not had an opportunity to make this actual cross as yet, due chiefly to the difference in flowering dates, but a similar cross involving some of the diploid S. African species (Frontispiece *A*) and *G. byzantinus* (Frontispiece *N*), a hexaploid, has been made. This same type of cross was reported nearly 50 years ago by Beal[6]

Over one hundred years ago Dean Herbert[12] was successful in combining many diploid species into one hybrid. This is clearly indicated by our results (Frontispiece *B, C, D, F, G*) and we now have some hybrids with seven species involved in their parentage. Time is the only factor which has prevented us from increasing that number. A similar hybrid with only five species is presented in Frontispiece *G*.

One of the critical points in the history of Gladiolus has been the reported crosses involving tetraploids and diploids. This seemed to be the hereditary bridge over which many of the diploid characters have entered into certain present tetraploids. That such hybrid triploids (Frontispiece *H, I, J, L, P*) can be formed is evident and we have made over two hundred different ones. The

♀ \ ♂	30	45	60	75	90	120	138	180
30	+++	+++	++	++	+	+−	+−	+−
45	++	+	++	+	+−	−	0	+−
60	++	+	+++	++	++	++	+++	++
75	+−	0	+	−	++	−	−	−
90	+−	−	+	+−	++	++	−	−
120	−	0	−	0	−	−	0	+++
138	+−	0	0	−	0	0	0	0
180	0	0	0	0	0	0	0	0

GLADIOLUS CROSSES MADE
Figure 1

The chromosome constitution of gladiolus varies from 30 (diploid) to 180 (dodecaploid). This chart shows the 64 possible crosses between the various types. +++ = 50-100%; ++ = 25-50%; + = 5-25%; +− = Rare; − = Negative; O = Not made.

A TRIPLE HYBRID

Figure 2

This showy hybrid has a complex ancestry as follows: [Professor Donders (60) × *G. tristis* (30)] × *G. tristis* (30). It is an aneuploid, and fertile.

most interesting point (Figure 1) is that many, used mostly as seed parents, are partially fertile and, when backcrossed with either their parents or similar types, some of them form progeny (Frontispiece *A*). We now have the chromosome numbers of many of these second generation crosses and the results will be presented separately. Most of them are aneuploids. It might be well to mention that some of these aneuploids are also fertile (Figure 2).

The widest cross involving a diploid species was a diploid-dodecaploid cross made in 1940. This represents the widest possible combination. Another wide cross is presented in Frontispiece *E*.

The bulk of the commercial types of Gladiolus are tetraploids and it is apparent that, once they are formed, they represent an extremely plastic group with reference to hybridization. They are not only easily crossed with diploids, triploids, and other tetraploids, but also with the higher polyploids (Frontispiece *M, O, R*). The pentaploid types previously reported[2] undoubtedly represented hybrids between the tetraploid varieties and such species as *G. psittacinus* and *G. dracocephalus* which are hexaploids. Like the triploids, the pentaploids which we have produced are partially fertile when backcrossed with their parents or similar types. The progeny of such crosses are aneuploids. This again may account for the presence of characters in the tetraploid summer-flowering types which are truly of hexa-

ploid origin. Our information concerning hybrids between the higher polyploids is not exhaustive enough at this time to warrant any conclusions. They represent two distinct types of species: the so-called Eurasian group and the tropical African group. The Eurasian group crosses easily with each other, even though their chromosome numbers are different, but we have had considerable difficulty with germinating apparently good seeds.

The information presented above is the usual result experienced by the students of many genera. Either experimentally or by the observation of chromosome conditions in suspected hybrids it has been shown repeatedly that interspecific hybridization is possible and more than likely it is one of the chief factors in the phylogenetic development of any group of plants. Hybridity is the basis of allopolyploidy as an evolutionary principle. The work on *Viola*,[4, 10] *Chrysanthemum*,[32] *Triticum, Aegilops*, etc.,[1, 30] *Nicotiana*,[11] *Narcissus*,[24] *Rosa*,[9] *Tulipa*[35] and many others have shown that interspecific hybridization must have been a factor in their development. The presence of many aneuploids in *Iris*,[16, 27] suggests that a great deal of interspecific hybridization has occurred there, as it appears to have in Gladiolus.

Summary

1. The heteroploid nature of the genus is confirmed and extended.

2. Hybrids can be made between species representing the limits of the genus, as measured by chromosome number, but the comparative success is less as such limits are reached. This confirms the recorded history of the development of the commercial gladiolus.

3. Some of the triploids and pentaploids are fertile and aneuploids are produced. Some of these aneuploids are now producing progeny. This may show the path by which characters of diploid and hexaploid species have been transmitted to commercial tetraploids.*

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*The author wishes to acknowledge the valuable assistance of Mr. R. E. Jones in making, recording and growing many of these hybrids.

CHROMOSOMES WITH TWO SPINDLE ATTACHMENTS*

In the Brazilian Scorpion (*Tityus bahiensis* Perty)

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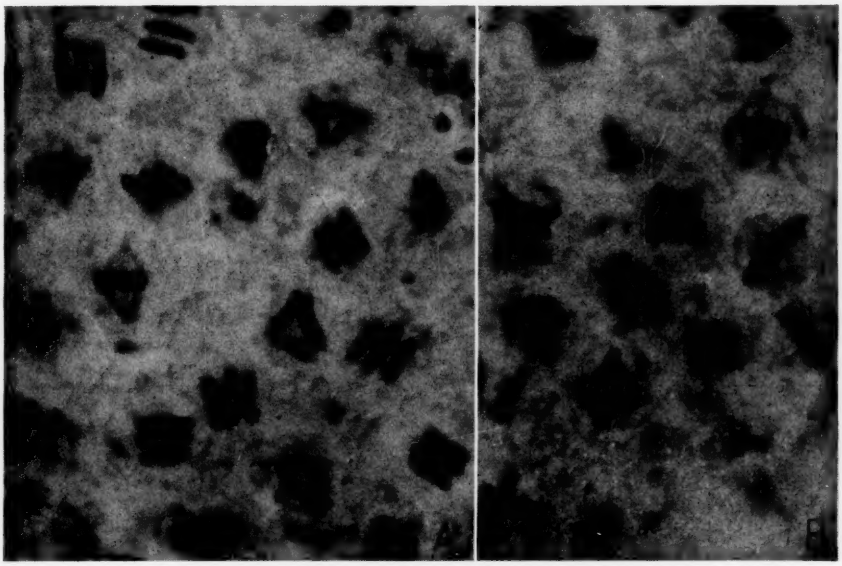


SPERMATOCYTE CHROMOSOMES OF TITYUS
Figure 3

A—Metaphase of the first spermatocyte division showing the bivalent chromosomes arranged in groups of three. In the left center is shown a meiotic division in which the condensed paired chromosomes are on the equatorial plate. *B*—A stage preceding metaphase showing the larger chromosomes already attached to the spindle.

THE chromosome number of the Scorpions is generally high, reaching not rarely 70 to 100 (Bresslau and Harnisch,[1] Wilson[8]). In examining some slides of embryonic tissues of a Brazilian species (*Tityus bahiensis* Perty) belonging to the family Buthidae I was greatly surprised in finding only six chromosomes. The material seemed to me very adequate for cytological investigations, so that I soon prepared many slides with sections of the testis for a study of the spermatogenesis.

Method

After removing the sting and the appendages the animal is rapidly opened, the testis dissected out and plunged immediately into the fixing fluids. (For technique see Piza[2]). The best results were obtained with Navashin and Bouin's method as modified for insects by Carothers. Paraffin sections, 8 to 10 micra thick, were made and stained with Heidenhein's hematoxylin. The aceto-carmine smear method gave always very fine slides.

*By spindle attachment the author does not necessarily mean kinetochore.

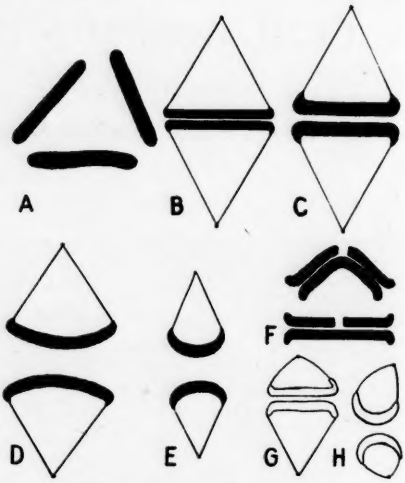
THREE PAIRS OF CHROMOSOMES
Figure 4

Metaphase plate of the spermatogonium, showing the six chromosomes present in the nucleus prior to meiosis.

Results

First spermatocyte division—All phases of meiosis can be easily observed.[3] But, what immediately attracts the attention of the observer is the metaphase of the first division of the spermatocytes. The polar views of this phase show three large rod-shaped bivalents disposed variously on the equatorial plate. When this plane coincides with the optical one, it was noticed that the bivalents often form a triangle (Figure 5*A*). The lateral views of the metaphase chromosomes show in the clearest way that the paired elements are perfectly separated throughout their whole length, both extremities of each one being turned towards the corresponding pole (Figure 5*B*). The repulsion at the two ends is therefore very pronounced. In each of the four extremities an element of the spindle (fibre or bundle of fibres) may be seen connecting the chromosomes with the poles. The spindle substance contained within the triangle formed by the body of the chromosomes and the filaments attached to their extremities constitutes a sort of very thin film of fibrilar structure. The spaces left between the chromosomes when they are parallel to each other and placed perpendicularly to the optical plane show clearly. The film just referred to was already discussed in another paper.[4]

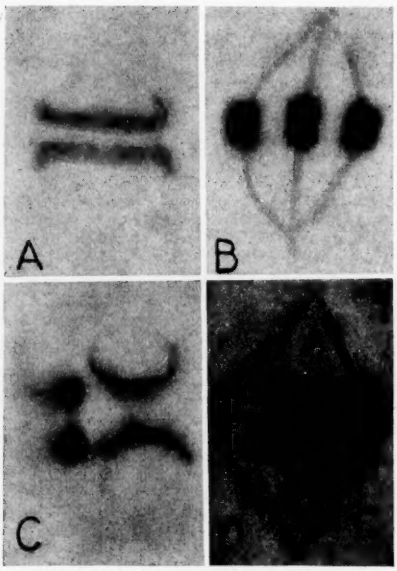
Anaphase—In the beginning of this phase the chromosome mates separate very slowly from each other in perfect parallelism, having only their extremities more and more turned apart (Figure 5*C*). Later the chromosomes make a regular bend towards the poles, showing in this manner they are attached to the spindle by the extremities and not along the entire body as might be assumed at the first glance (Figure 5*D*). Spontaneous breakages observed in some cases served to confirm the existence of the two points of attachment, since the fragments not only have been preserved but they have mated with the corresponding parts of the homologous chromosomes (Figure 5*F*). (Piza.[6])



DETAILS OF MEIOSIS
Figure 5

A—shows a metaphase of the first division of the spermatocyte in *Tityus*. *B*—shows a lateral view of a bivalent during the first meiotic division, *C* and *D*—are later stages of this division, showing the chromosomes being drawn toward the poles by the spindle fibers attached to each end of the chromosome. *E*—shows an advanced anaphase during second meiotic division. *F*—shows the pairing of chromosome fragments and unbroken partners. On account of the dual spindle fibers, fragments can be carried through the meiotic division. *G* and *H*—show chromosomes at the beginning of a meiotic anaphase and at an advanced stage of anaphase. These are drawings from the preparation shown in Figure 6*A* and 6*C*.

Second division—At metaphase of the second division of the spermatocytes the chromosomes, which are markedly shorter and thinner, have the same general aspect observed in the first division, that is, they are well separated and have the ends turned towards the poles. At anaphase the chromosomes acquire a very pronounced arch-shaped form, assuming sometimes the appearance of miniature



DETAILS OF DOUBLE SPINDLE ATTACHMENTS
Figure 6

A and *B*—show early stages of anaphase in meiosis. In *A* the spindle fibers scarcely show but the turned back ends of the paired chromosomes are clearly visible. In *C* (the right-hand pair) the spindle fibers at the end of the chromosomes could be distinguished in the preparation, as schematized in Figure 5*H*. *B*—shows a meiotic figure where the paired chromosomes are seen from the ends. *D*—shows a bivalent chromosome just before the pairs begin to separate. The two spindle fibers can be clearly seen.

parachutes falling down from the equator to the poles (Figure 5*E*).

Mitosis of the spermatogonia—In the spermatogonial divisions it is very difficult to make a direct analysis of the spindle attachments. In an earlier paper the author[4] considered the very particular behavior of the metaphase chromosomes as a good proof of their dicentricity. These long, curved and often sinuous chromosomes have all parts of their body lying on the plane of the equator so that excellent polar as well as lateral views may be obtained (Figure 4). This is to be interpreted, as was emphasized in the mentioned paper,[4] by assuming that the chromosomes, keeping the two extremities in the plane of the equator have the natural tendency for adjusting their entire body to the same plane. The metaphase plate gives rise to two symmetrical anaphase ones, in which the chromosomes retain approximately the same bends and sinuosities visible before the separation. This situation makes difficult an exact judgment of the manner in which the chromosomes are inserted in the spindle. The parallelism of the anaphase plates maintained for a long while suggests that the entire body of the chromosomes may be adherent to the elements of the spindle forming the film referred to above, as was reported by Schrader[7] with regard to the X-chromosome of *Protenor*. But this may be due equally in part to the high degree of viscosity and rigidity of the chromosomes, in part to the action of the forces operating during anaphase, which orient the points of attachment constantly towards the poles. Sometimes I was able to observe the separation of the metaphase chromosomes beginning at the extremities. This confirms the observations made in both meiotic divisions.

Discussion

Until the present time the chromosomes, at least in the Metazoa, are universally considered as possessing a unitary point of insertion to the spindle, sometimes marked by the presence of a corpuscle generally called the centromere. Only the natural compound structures (*Ascaris*) or the abnormal ones originated from breakages and readjustment of parts may have more than one point of attachment. Chromosomes naturally provided with an insertion point at each extremity were never supposed to exist. The X-chromosome of *Protenor* discussed by Schrader[7] showed that the chromosomes are not always attached to the spindle in the universal manner. However, the comportment of this chromosome at the second division of the spermatocytes brought some difficulties to the interpretation of what is actually occurring in the first division. But, the behavior of the chromosomes of *Tityus*

bahiensis leaves little doubt concerning the existence of two spindle attachments. From what I could observe[5] in another species of Scorpion (*Tityus serrulatus*) with 12 chromosomes in the embryonic tissues, I suspect that the same situation may be found again if the spermatogenesis were examined. It is easy to imagine the complications this finding affords to the mechanism of separation of chromosomes as well as to some general theories like that of chiasmata formation and terminalization, spiral structure, etc.

Summary

The chromosomes of *Tityus bahiensis* are normally provided with a spindle attachment at each extremity. The repulsion of the ends at metaphase of the first and second meiotic divisions, the bowing towards the poles at anaphase and the preservation of the pieces originated from spontaneous breakages are the best demonstration of their terminal differentiation.

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PROCEEDINGS OF THE EDINBURGH GENETICS CONGRESS

THE Seventh International Genetical Congress, held in Edinburgh during the last fateful week of August 1939, will go down in history for a number of reasons. Originally scheduled to be held in Moscow in 1937, this Congress was a "war baby" right from the start. Certain chapters of the story of the postponement of the Congress have already been given in the Journal. Very likely all the incidents leading up to the Russian non-participation in this Congress will never be told. The official story, received by Secretary General Crew on August 4, 1939, is given in Dr. Crew's introduction to the proceedings. Surely the battle of Marxian genetics versus "classical genetics" must have been a considerable element in this change of view. To search this "record" too diligently with the Nazi mechanized horde pushing at the gates of Moscow would but add to the silly futility of the recent sound and fury over whether an unbaptized party member should be given weapons to do an urgent job which each day brings nearer to our own front door. And a door which we desperately need time to barricade with tanks, planes, guns and ships.

Whatever the reason for the changed place of meeting, a genetical Congress was scheduled to be held in Edinburgh on August 23-30, 1939. And during that fateful week a Congress was held in Edinburgh. That this should have been so is a lasting monument to the courage and persistance of British geneticists in general and of the Organizing Committee of the Seventh International Congress in particular. In the dark months between Munich and the march into Poland (which began while the Congress was still in session) it had become increasingly clear that "peace for our time" was an empty dream. The British Committee made up its mind in those fear-charged months that any disaster short

of war would not stop the gathering of geneticists from the ends of the earth. Most of the disasters short of war came to pass, culminating after the program was being printed, in the withdrawal of the Russian delegation.

Not only did this Committee make arrangements for the Congress and hold it just as the guns of World War II were booming across a startled world, but in a world at war the Committee has completed its work and has recently published the *Proceedings of the Seventh International Genetics Congress.** This is further striking testimony to the persistance and courage of British science workers in a world at war. The reviewer is astonished to receive with increasing frequency manuscripts for publication from British genetics laboratories in the midst of the Battle of Britain. This courageous determination to keep the laboratory lamps alight must thrill and inspire science workers everywhere.

In spite of the urgent rumors of war, over six hundred geneticists living in sixty-two countries had applied for membership in the Congress. It will never be known how many of these actually reached Edinburgh, because after the Congress convened some were forced to leave before they had registered. About half the total registration appeared to have been present at the Congress at least for a few hours. Some 150 delegates from the United States, and from other countries so distant that immediate return was impossible, furnished the nucleus which continued the meetings.

The Congress was divided into nine sections: *A*—Gene and Chromosome Theory; *B*—Cytology; *C*—Physiological Genetics; *D*—Animal Breeding in the Light of Genetics; *E*—Plant Breeding in the Light of Genetics; *F*—Human Genetics; *G*—Genetics in relation to Evolution and Systematics; *H*—Statistical Genetics; *I*—Genetical Aspects of Growth Normal and Abnormal. In the proceedings, 331 of the papers submitted for the program are included.† These are arranged alphabetically according to the name of the author. They vary in length from a short paragraph to five and a half pages. This recordly long abstract, with over two pages of literature citations, is a survey of studies of point mutations by Timofeef-Ressovsky. A vast array of different aspects of theoretical and applied genetics are passed in review. Since the abstracts are arranged according to the name of the author, it is necessary to refer to the program showing the papers read in the various sections to survey what transpired at the congress with regard to any specific genetic problem. While this may be advanced as an objection to the present arrangement, difficulties could also be found for almost any other way that the papers might have been arranged.

It is interesting to review the proceedings of the 1939 Congress in the light of Morgan's presidential address to the 1932 Congress. In 1932 there may have been a suspicion that genetics was beginning to reach a dead end. Muller had documented his discovery of induced mutation at the 1937 Congress in Berlin, and during the succeeding five years no major revolution in genetic procedure or outlook had occurred. Between 1932 and 1939 two very important advances were made: the discovery that the giant salivary gland chromosomes of Drosophila were exceptional material for cyto-genetic studies and for studies of the structure of chromosomes; and the discovery that colchicine and certain other chemicals had the property of increasing the number of chromosome sets in the cell nucleus of plants and possibly of some animals. Neither of these discoveries has yet been fully exploited.

Out of the salivary gland chromosomes discovery have come entirely new ap-

*Proceedings of the Seventh International Genetics Congress, Edinburgh, Scotland, 23-30 August 1939. Edited by R. C. Punnett, M.A., F.R.S. Issued as a supplementary volume of the *Journal of Genetics*. Pp. 336. 42 Shillings. Cambridge University Press. 1941

†The Russian contributions are not included. They have been made available (some as abstracts) in DIS and as supplementary documents (see this JOURNAL, August, 1941).

proaches to the problem of localizing the position of the gene within the chromosome. In the last year or so attempts to discover by micro-analysis and by spectographic methods the actual chemical structure of individual bands of the salivary gland chromosomes offer still unexplored possibilities of chemical and physical analysis of the gene. So in 1941 we find ourselves on the borders of a new world of genetic discovery, — a world whose extent and riches it is impossible yet to assess.

The discovery of methods of inducing polyploidy through chemical action, with which the names of the Cold Spring Harbor group and the Nebels at the Geneva Experiment Station are associated, has also only begun.* In 1939 only the bare fact that induced polyploidy in plants was now an experimental possibility had been established. Now we know that a number of chemicals produce genome multiplication, and by different effects on the cell metabolism. The practical and theoretical implications of such hopeful developments give us confidence that when peace returns to the world again, and the Eighth Genetics Congress is held, that there will be no dearth of most novel and stimulating material over which the program committee will have to ponder in making its arrangements.

Two plenary sessions of the Congress were held. The first on August 23 heard Dr. Mohr's history of the negotiations of the Permanent International Committee which led first to scheduling the Congress in Moscow and finally to holding the Congress in Edinburgh. Since the presidency was vacant through Dr. Vavilov's absence and since he had stated in an earlier letter that he could not serve as the President of the Congress, Dr. Crew was unanimously invited to accept the Presidency. Following this, Vice-presidents from forty-one participating countries were elected. A Permanent International Committee to hold office until the next Congress was appointed. It consisted of: Huskins (Canada), Winge (Denmark), Ephrussi (France), Von Wettstein (Germany), Crew (Great Britain), Ghigi (Italy), Sirks (Netherlands), Mohr (Norway), Dahlberg (Sweden), Ernst (Switzerland), Demerec (U. S. A.). A Resolutions Committee was also elected.

At the second plenary session held August 26, the Permanent Committee reported that two invitations had been received to hold the Eighth Genetic Congress: one at Rome for 1942, and one in California in 1944. Since world conditions made a decision impossible at that time, the Committee requested authorization to decide the time and place of the next meeting at a later date. This was ratified by the Congress. The Committee also moved and the Congress adopted the motion, that later Congresses be granted entire autonomy regarding the publication of *Proceedings*.

The Resolutions Committee reported a resolution put by Dr. Crew that: "It is desirable that the Congress should set up an International Committee which should devise a scheme or schemes whereby animal and plant stocks of genetical importance might be maintained in times of emergency." One of the sub-committees of the Congress later took some action with regard to genetic stocks of mice. This was published in the JOURNAL some month ago (September 1939). It was suggested that "genes which have died out are as irretrevably lost as an extinct animal or plant species."

The gadgeteering of the physical sciences has given us the Industrial Revolution, which in the hands of indifferent men and of men of ill will, has brought our culture to the verge of destruction. The sciences of life, of which genetics is one of the basic foundation stones, offer the hope that the things-madness of the nineteenth century may be a nightmare which will be ended by the year two thousand through a Vital Revolution based on this still-so-new knowledge of life processes.—R. C.

*See HAVAS, L. J. *Jour. Hered* 31:115-117 for a chronology of early work with Colchicine.

INTERACTION OF ANTIGENS IN DOVE HYBRIDS

Pictorial Representation of the Relationship of the Cellular Antigens of Two Dove Species and Their Hybrids*

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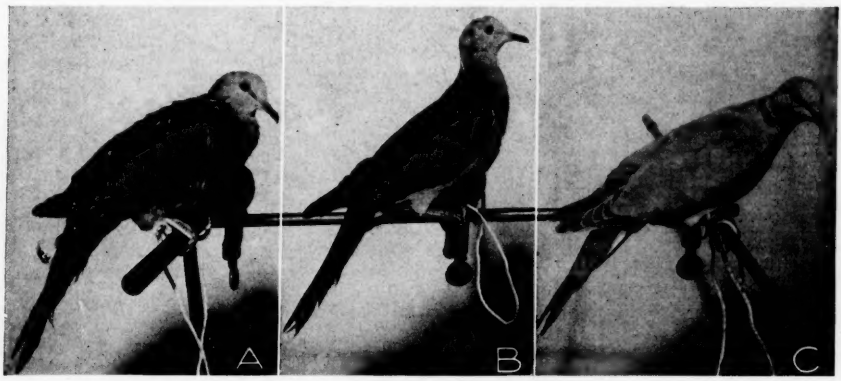


DOVE SPECIES AND HYBRID

Figure 7

A—shows the Pearlneck dove; *B*—the Pearlneck-Ring dove hybrid; and *C*—the Ring dove. The blood of the hybrid contains most of the antigens of the two parent species, plus some special antigens of its own.

AN earlier report[1] gave a pictorial representation of hypothetical antigenic differences between the blood cells of two species, Ring dove (*Streptopelia risoria*) and Pearlneck (*St. chinensis*). These species were represented as *sharing* one antigen (represented by a triangle in Figures 8 and 9) in their red blood cells, and the corpuscles of each species were differentiated from those of the other by a *species-specific* antigen. Actually, studies[2,3,4] have revealed that there are many cellular antigens *species-specific* to each species. And it appears probable that there are several cellular characters *common* to both species. In our opinion, the *common* antigens are much more numerous in each species than the *species-specific* antigens, although experimental analysis of the number of the *common* antigens is lacking. The previous pictorial symbolization did not take into consideration the multiplicity of common and specific antigens, but merely employed the simplest explanation of the genetic relationships.

A geneticist would naturally inquire whether, in these particular characters, the hybrid is intermediate between the two species, showing a blending effect of the genes, or whether there is a preponderant likeness to one or the other parent. Actually, experimental evidence has revealed that the hybrid possesses all the *common* as well as nearly all the *species-specific* characters of both parents. Further, the hybrid corpuscles are endowed with one or more "new" components which are not found, as such, in

*Paper No. 289 from the Department of Genetics, Agricultural Experiment Station, University of Wisconsin, Madison, Wis.

the corpuscles of either parent. Photographs of the Pearlneck, Ring dove, and their species hybrids are presented in Figure 7.

The present paper is an extension of the preceding report, and demonstrates pictorially the antigenic relationships of the two dove species and their hybrid. Many details of technique will be omitted, since they were considered in the earlier report.[1] To provide uniformity, the same symbols are employed in the figures as were previously used.

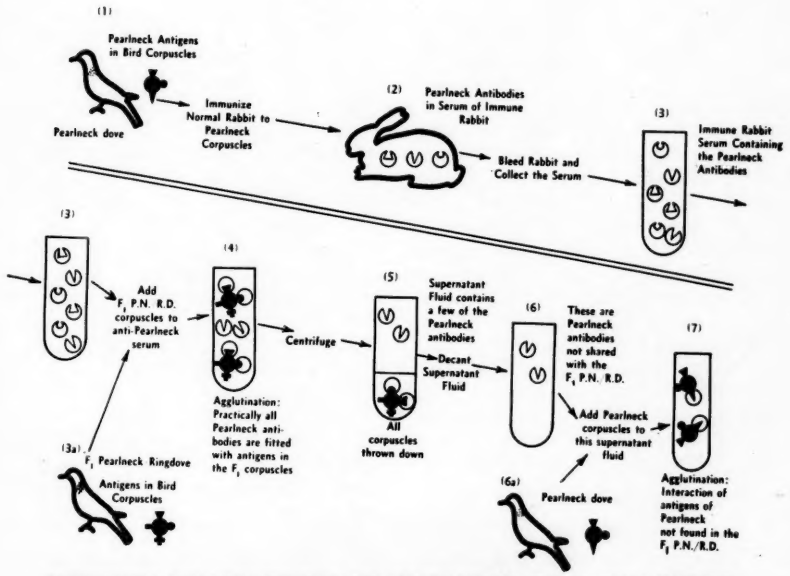
When an anti-Pearlneck serum is mixed with the erythrocytes of Pearlneck, Ring dove, or the F_1, an agglutination of each kind of corpuscles occurs in approximately the same dilutions of antiserum. Antisera to Ring dove or to the F_1 reveal similar relationships, showing that a considerable antigenic complex is shared by the two species and their hybrid. This "common" antigen or group of antigens has been symbolized with the "triangle."

The agglutination of the corpuscles of the species and their hybrid by the unaltered antiserum, as described above, will not serve to differentiate the species. However, after Pearlneck antiserum, for example, is mixed with an excess of Ring dove cells, the test fluid or "reagent" remaining after absorption no longer reacts with Ring dove cells, since the antibody for the common antigen (the "triangle") has been removed from the serum, — the agglutination of Pearlneck cells being by virtue of the interaction of the antigen particular to Pearlneck (the "circle" antigen) and its specific antibody. Experimental results[2] have shown that the F_1 cells will be agglutinated by this reagent to the same extent as are Pearlneck cells, and the conclusion appears valid that all or a major part of the antigen peculiar to Pearlneck cells is also present in those of the species hybrid.

If the antigens peculiar to Pearlneck are wholly contained in the species hybrid, and if these birds show no individual differences in specific Pearlneck characters, absorption of anti-Pearlneck sera by any F_1 cells should remove from the antiserum all the antibodies, for both *specific* and *common* antigens. Actually, the antiserum when absorbed with the corpuscles of individual species hybrids, agglutinated the cells of Pearlneck at a low dilution, but not those of either Ring dove or the F_1.[2] (No more than a faint indication of individual differences was noted among the species hybrids which were tested, suggesting that at least one of the Pearlneck parents of these birds was not heterozygous for the particular Pearlneck antigens.) Therefore, it may be concluded that the cells of the F_1 contained all the *common* antigens of the parental species (otherwise this reagent would have agglutinated Ring dove cells), but lacked one or more antigens of the Pearlneck species. In terms of our hypothetical representation, they might possess only a part of the "circle" antigen.

For purposes of clarity, however, we have assumed that this result requires an additional antigen particular to Pearlneck, which in Figures 8 and 9 is represented by a "dagger." Pearlneck cells, then, possess the "triangle" antigen in common with Ring dove and the F_1, the "circle" antigen shared only with the F_1, and the "dagger" antigen which is present only in Pearlneck and distinguishes these cells from those of both Ring dove and the species hybrid.

By methods exactly paralleling those just described, the relationship of the antigens of Ring dove to those of Pearlneck and the F_1 can be determined. Since Ring dove antiserum, when absorbed by Pearlneck cells, will agglutinate Ring dove cells and not those of Pearlneck, evidence of at least one character peculiar to Ring dove (the "bar" antigen) is obtained. This reagent reacts with F_1 cells as well as with those of Ring dove, so presumably most of or all the "bar" antigen of Ring dove is present also in F_1 cells. When corpuscles from an individual F_1 are used in the exhaustion of Ring dove antiserum, the resulting reagent has always agglutinated Ring dove cells but not Pearlneck cells and not definitely those of any other F_1. Thus Ring dove antiserum possesses an antibody for its homologous cells that has no receptor in F_1 cells, and this anti-


(1)
Pearlneck Antigens in Bird Corpuscles
Pearlneck dove
Immunize Normal Rabbit to Pearlneck Corpuscles
(2)
Pearlneck Antibodies in Serum of Immune Rabbit
Bleed Rabbit and Collect the Serum
(3)
Immune Rabbit Serum Containing the Pearlneck Antibodies
(3)
Add F1 P.N. R.D. corpuscles to anti-Pearlneck serum
(4)
Centrifuge
Agglutination: Practically all Pearlneck antibodies are fitted with antigens in the F1 corpuscles
(5)
Supernatant Fluid contains a few of the Pearlneck antibodies
Decant Supernatant Fluid
All corpuscles thrown down
(6)
These are Pearlneck antibodies not shared with the F1 P.N. R.D.
Add Pearlneck corpuscles to this supernatant fluid
(7)
Agglutination: Interaction of antigens of Pearlneck not found in the F1 P.N./R.D.
(3a)
F1 Pearlneck Ringdove
Antigens in Bird Corpuscles
(6a)
Pearlneck dove

ANTIGENIC RELATIONSHIPS OF PEARLNECK DOVE AND HYBRID
Figure 8

This diagram shows the procedure to demonstrate that the Pearlneck dove has specific antigens which the Pearlneck-Ring dove hybrid lacks. A similar procedure shows that the Ring dove parent also has specific antibodies lacking in the hybrid. See text below.

gen is represented as an "arrow" in Figure 9. Ring dove cells then are depicted as containing three different antigens, viz., one which is found only in Ring dove, not in either the F_1 or Pearlneck (the "arrow"), another which is found in both Ring dove and the F_1, but not in Pearlneck (the "bar"), and a third which is common to the three kinds of cells (the "triangle").

The relationship of the F_1 to each of the parental species can be tested by absorbing an antiserum to F_1 cells by Ring dove and Pearlneck, respectively, and testing these reagents with the three kinds of cells. The results of such tests[2] bear out the conclusions that the hybrids contain most but not quite all the cellular antigens of both parental species. Furthermore, when an F_1 antiserum is exhausted by the corpuscles of both Pearlneck and Ring dove, the reagent will agglutinate F_1 cells but not those of either Pearlneck or Ring dove.[2] Thus a "new" or "hybrid substance" (the "cross" antigen of Figures 8 and 9) is present in the cells of the species hybrid.

If these cellular characters are caused by genic action, then in the F_1 a homologue will be found only by virtue of the action of the gene, which in the parental species produces the substance *common* to both species. But the genes which in each species produce species-specific effects will in the species hybrid be simplex. For example, assuming in Pearlneck a particular gene which produces the "circle" antigen, and another producing the "dagger" character, the simplex gene for the "circle" antigen produces the same character in the F_1 as in Pearlneck, and the haploid and diploid effects of this gene are the same. An alternative explanation would state that, in the F_1, the simplex gene for the antigen specific to Pearlneck produced only a part of the antigens found in Pearlneck and produced by duplex genes. However, in part because of the finding of many characters specific to each species, and the

probable linkage of three or more of these to the "hybrid substances," this latter explanation is deemed improbable.

Because of the absence in the F_1 cells of the "dagger" character of Pearlneck and also of the "arrow" antigen of Ring dove, it appears that the most probable explanation of their absence is that their respective causative genes interacted in the F_1 to produce the "hybrid substance" (the "cross" antigens). Further details of this relationship will be given elsewhere. In human cells, the allelic genes for the *A* and *B* characters produce the full quantitative expression of both *A* and *B* in the heterozygote. This is also true of the *M* and *N* characters, where homozygous for either, or heterozygous; *M* and *N* together produce the same effect as in the homozygote for either.

Steps in Antigen Analysis

The several steps in the elucidation of the species and species-hybrid relationships are given below, and are presented pictorially in Figures 8 and 9.

Figure 8. (1) The Pearlneck corpuscle is represented with its three antigenic receptors — "triangle," "circle," and "dagger." These corpuscles, when inoculated into a normal rabbit, stimulate in it the respective antibodies to the Pearlneck antigens.

(2) and (3). As was explained in the previous publication, the antigen-antibody specificities may be represented by a lock-and-key relationship. By immunization, then, antibodies have been stimulated in the serum of the rabbit that fit the "triangle," "circle," and the "dagger" antigens in the erythrocytes of Pearlneck.

(3a) The four different antigens of the red blood corpuscles of the species hybrid of Pearlneck and Ring dove are represented as "triangle," "circle," "bar," "cross."

(4) When the corpuscles of the F_1 Pearlneck $\times$ Ring dove are added to the anti-Pearlneck serum, agglutination occurs. This agglutination is represented as involving the "triangle" antigen, since it occurs in both species and the hybrid; and the "circle" antigen, which is shared by Pearlneck and the F_1, but not by Ring dove. The "bar" antigen of the F_1 is not involved in this agglutination, since antibodies to it are not present in a Pearlneck antiserum. The "cross" antigen, too, finds no antibody counterpart, since the "cross" is not found in the Pearlneck antigenic complex. Furthermore, there is one antibody, that stimulated by the "dagger" antigen of Pearlneck, which is not "fitted" by any of the antigens of the F_1. Hence, it remains free and unattached in the antiserum.

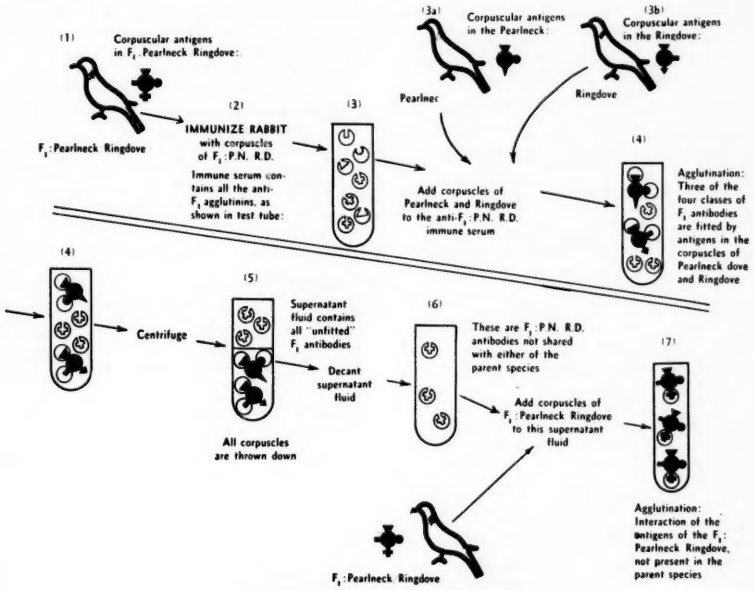
(5) and (6) The absorbing mixture is centrifuged and all the corpuscles are thrown down. If an excess of F_1 corpuscles has been added, and the antiserum has been "completely" absorbed, there are then no antibodies left in the supernatant serum which have antigenic counterparts in the F_1 corpuscles.

(7) When Pearlneck corpuscles are added to the supernatant fluid, agglutination occurs by virtue of the union of the "dagger" antigen and its antibody, in the Pearlneck corpuscles and antiserum, respectively. That is, the "dagger" antigen of Pearlneck is not found in the hybrid.

An anti-Ring dove serum, absorbed by the F_1 Pearlneck $\times$ Ring dove corpuscles, presents a parallel sequence of events. That is, the Ring dove possesses in its corpuscles an antigen not found in corpuscles of the F_1 hybrid. This antigen is symbolically represented in Figure 9 as an "arrow." The demonstration of the "arrow" is not given here, for it is essentially the same as that presented above for the "dagger" antigen.

Antigens Peculiar to the Hybrids

Experimental results, as stated earlier, have revealed that the species-hybrid of Pearlneck $\times$ Ring dove possesses antigenic components not found as such in either or both of the parental species.[3] To detect the presence of this antigenic complex, it is necessary to inoculate a rabbit with the corpuscles of the hybrid. The anti-hybrid serum is then absorbed by the cells of both Pearlneck and Ring dove. After absorption, the reagent will no longer agglutinate the corpuscles of either of the two parental species but will agglutinate those of the hybrid. The


(1)
Corpuscular antigens in F_1 Pearlneck Ringdove:
F_1: Pearlneck Ringdove
(2)
IMMUNIZE RABBIT with corpuscles of F_1: P.N. R.D.
Immune serum contains all the anti-F_1 agglutinins, as shown in test tube:
(3)
(3a)
Corpuscular antigens in the Pearlneck:
Pearlneck
(3b)
Corpuscular antigens in the Ringdove:
Ringdove
Add corpuscles of Pearlneck and Ringdove to the anti-F_1: P.N. R.D. immune serum
(4)
Agglutination: Three of the four classes of F_1 antibodies are fitted by antigens in the corpuscles of Pearlneck dove and Ringdove
(4)
Centrifuge
(5)
Supernatant fluid contains all "unfitted" F_1 antibodies
Decant supernatant fluid
All corpuscles are thrown down
(6)
These are F_1: P.N. R.D. antibodies not shared with either of the parent species
Add corpuscles of F_1: Pearlneck Ringdove to this supernatant fluid
(7)
Agglutination: Interaction of the antigens of the F_1: Pearlneck Ringdove, not present in the parent species
F_1: Pearlneck Ringdove

SPECIFIC HYBRID ANTIGENS
Figure 9

Procedure to demonstrate that the hybrid contains unique antibodies different from those contributed by either parent. See text below.

only reasonable conclusion, therefore, is that the hybrid has one or more antigens that the parents lack. This antigenic complex is symbolized with the "cross" on the hybrid corpuscle. A pictorial representation of the method of detecting the "cross" antigen is given in Figure 9, and outlined below.

Figure 9. (1) The F_1 Pearlneck $\times$ Ring dove corpuscle is represented as having four antigens, as shown in Figure 8, viz., "triangle," "circle," "bar," and "cross."

(2) and (3) A rabbit immunized to the cells of the hybrid produces an antiserum that contains antibodies to the four different antigenic receptors on the hybrid corpuscle.

(4) Cells of Pearlneck and Ring dove, when added to the anti-hybrid serum, are agglutinated. The antigens and their respective antibodies which effect this agglutination are those in common between the two species and the hybrid ("triangle"), those shared by Pearlneck and the hybrid ("circle"), and those shared by Ring dove and the hybrid ("bar"). The Pearlneck specific antigen, "dagger," and the Ring dove specific antigen, "arrow," do not enter into this agglutination, since they are not found in the F_1 corpuscles and hence cannot have antibody counterparts in the hybrid antiserum. Neither does the hybrid specific "cross" antigen influence this agglutination, since it, in turn, is not present in either of the parental species.

(5) and (6). The absorbing mixture is centrifuged, and all the corpuscles are thrown down. The antibodies to the "cross" antigens, which remain "unfitted," remain in the supernatant fluid.

(7) Agglutination occurs. This fact assures us that there is a hybrid-specific antigen, not present as such in either or both parents. This antigen is the only one contained in the hybrid corpuscles which brings about agglutination. All the antibodies to the other hybrid antigens have been removed from the anti-

serum during the preceding absorptions with the corpuscles of the parents.

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Gene-Made Trephines *vs.* Homemade Trephines

To the Editor:

In Volume 32, No. 9 of the Journal W. M. Goldsmith has an article on "Bilateral Fenestrae in the Parietal Bones." I have no particular quarrel with the author's general exposition of these natural openings in the cranial vault but *there is one point of fact that creates an erroneous impression* and I feel it should be brought to the author's notice and corrected. He refers to a skull with paired parietal openings on public exhibit at the American Museum of Natural History and figures it by a crude line drawing. This he says is mislabeled as being trephined and suggests that museum curators have not infrequently misrepresented similar skulls as trephined whereas they are examples of the "Catlin Mark" or natural defects of ossification.

Since the author fails to identify by its catalogue number the skull in our museum to which he refers, I have had to compare his line drawing with all the trephined skulls we have on view. There is only one skull which can be said to resemble his drawing and this I have re-examined. The openings bear the *typical signs of a healed trephine with beveled edges and have repair on the inner table.* Unless Dr. Goldsmith can definitely establish that natural "Fenestrae" are similarly characterized it would, I think, be premature to relabel our trephined skulls.

H. L. Shapiro
Amer. Museum of Natural History

I regret Dr. Shapiro got the impression that I was focusing my criticisms on one particular specimen in the American Museum. I purposely refrained from using the catalogue number, hoping that the "crude line drawing" would represent the *type* of such "Catlin marked" skulls rather than a particular speciman.

The mere fact that a speciman has been in a laboratory or museum many years with the same labeling does not insure the accuracy of such labeling. I appeal to the various custodians of the "Catlin Mark" type of so-called "trephined" skulls to make a thorough study of their specimens and see if there is a dependable method of determining the difference between a skull-hole made by man and one produced by some variation in ossification. I appreciate Dr. Shapiro's statement that the openings in the particular skull "bear the typical signs of a healed trephine with beveled edges and have repair on the inner table." *Could not the same statement be made of a "Catlin Mark" healing?*

Whether the median ossification is complete before birth (as in case of the Indiana infant, Fig. 9, Page 304, Journal of Heredity, Sept. 1941) or delayed until near adult-hood, a healing process had to take place somewhat comparable to the healing necessary after a skull had been trephined. In each case would there not be signs of "healed" beveled edges with "repair on the inner table"? The natural "Fenestrae" of the Tulane Calvarium (Fig. 12, Page 307, Journal of Heredity, Sept. 1941) and X-rays of various "Catlin Mark" skulls certainly would indicate that the net result of the two "healing" processes would be similar.

While reviewing many skulls, as well as records in the literature, it became noticeable that in a considerable number of those having bilaterally "trephined" parietals, the fenestrae were round to oval, *in about the same position,* and bore a remarkable similarity in different skulls, *though their origin might be from widely separated parts of the globe.* Since these aborigines of thousands of years ago certainly were not in direct communication with each other, it would seem improbable that their primitive surgery would follow so consistent a plan. On the other hand, if these quite uniformly paired parietal fenestrae were produced by nature, we would be no more surprised at their similarity than we are at the similarity in case of syndactylism, brachydactylism, or any other human mutation or sport. We therefore, propose these queries, *Are these so-called "trephinations" not racial anomalies comparable to other variations which characterize Homo sapiens?* Were these two holes in most skulls not produced by nature rather than by some cruel, but well-meaning, medicine man or witch doctor? These and related problems merit further investigation.

William M. Goldsmith

Is it possible that prehistoric surgeons saw some magic advantage in following "nature's pattern" of trephining as revealed in a "Catlin-marked" family? This might make it very hazardous to classify all symmetrical trephines as "natural."—ed.

X-RAY AND ULTRA-VIOLET INDUCED MUTATIONS IN NEUROSPORA*

II. Ultra-Violet Mutations

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SINGLE spermatia were placed on agar plates containing clear Difco nutrient agar and exposed to the ultra-violet rays from a mercury vapor tube (Hanovia Sc-2537) producing nearly monochromatic radiation at a wave length of 2537 *A*. A water filter was interposed to eliminate the radiation of extremely short wave length. The lamp was placed 21 cm. from the surface of the agar at which distance it delivered 900 ergs per mm² per minute. The following tabulation is compiled from the total result of nine separate experiments:

Time of treatment Seconds	Lived	Failed to germinate	Percent survived
0	281	68	81%
10	145	30	83%
15	75	198	27%
20	40	127	24%
30	4	40	9%
40	6	135	4%

These data indicate that only four percent of the spermatia survived following an exposure of 600 ergs per mm.² Only three mutants were obtained, *Mutants U-10, U-13,* and *U-12.*

In an attempt to obtain a larger yield of mutants, the procedure was changed. Spermatia were treated suspended in a drop of water instead of on the agar plate. The intensity of radiation was decreased by increasing the distance to 44.5 cm. and 89.5 cm. and increasing the time of exposure. At 44.5 cm. the tube delivered about 200 ergs per mm² per minute, while at 89.5 cm. the delivery is about 50 ergs per mm² per minute. As soon as possible after treatment, a loop of the suspension was streaked on nutrient agar. The isolated spermatia that looked viable were each transplanted to separate tubes. It was not possible to determine exactly the percentage of survivors because the spermatia which germinated first, overgrew the agar. A rough estimate indicated that less than one percent of the spermatia survived compared to about 87 percent of the controls. The numbers of mutant and non-mutant survivors are shown below:

	44.5 cm. 200 ergs/mm²/min.		89.5 cm. 50 ergs/mm²/min.			
Time	6 min.	8 min.	16 min.	25 min.	32 min.	40 min.
Dose erg/mm²	1200	1600	800	1250	1600	2000
Mutant	4	11	2	1	4	10
Non-mutant	100	128	70	13	39	98
% mutation	3.8	7.9	2.8	7.2	9.3	9.2
Serial number of mutants	U-7	U-1	U-4	U-28	U-5	U-15
	U-22	U-2	U-6		U-8	U-21
	U-27	U-11			U-9	U-26
	U-35	U-16			U-14	U-29
		U-17				U-30
		U-18				U-31
		U-19				U-32
		U-20				U-33
		U-23				U-34
		U-24				U-36
		U-25				

105 controls yielded one degenerate phenotype. Mutant U-3 was obtained in an early unrecorded treatment.

"FLUFFY" COMPARED WITH ULTRA-VIOLET MUTANTS

Figure 10

Hyphae of a standard *fluffy* culture (*A*) viewed through the side of the small test tube in which a single spermatium had been planted, compared with the spermatial cultures (*B-D*) obtained from three of the mutants produced by ultra-violet treatment. These mutants carried both the *fluffy* gene and the ultra-violet induced mutation, and it is these cultures that were mated to wild-type in the analysis of the induced mutations. The photographs were all taken at the same magnification.

B—It can be seen that Mutant U-24 (*clustered-fluffy*) contains a denser and more branched growth of mycelia than the standard *fluffy* (*A*). In Mutant U-24 most of the growth was confined to the base of the tube. Mutant U-19 (*rainbow-fluffy—C*) the hyphae are coarser with more branching than the standard *fluffy*.

The differences apparent in these photographs could only be seen in detail under the microscope, but it was quite easy to distinguish the culture from each other macroscopically because there were many other clear cut differences in color, texture, distribution of hyphae, coloration of the substrate, etc., which distinguished the mutants from standard *fluffy* as well as from each other.

These double mutants carrying both the *fluffy* gene and the ultra-violet induced mutation gene were mated to wild-type. The mutant gene was separated from the *fluffy* gene by Mendelian segregation and the effect of the new mutant alone in the absence of *fluffy* then became

(*Continued on page* 437)

Detection of Mutation

The irradiated spermatia were obtained from the *fluffy* mutant, but since the ultra-violet experiments were made some months after the x-ray experiment, it was necessary to reisolate a fresh *fluffy* culture from a single ascospore. Cultures held for a few months are usually heterokaryotic. The culture used in the x-ray experiments was (—) sex, while the ultra-violet culture was (+). Figure 10 shows the appearance of standard *fluffy* under the microscope in comparison to three of the ultra-violet mutants. The photographs were taken through the wall of the culture tube. Familiarity with the organism is necessary to detect these mutants as variants of standard *fluffy* and the personal equation becomes a factor (as it always does in the detection of mutation) when one is selecting those mutants which alter the phenotype only slightly. Segregation at meiosis was proof of the genic nature of the induced mutation.

Classification and Description of Mutants

Gene Mutations

Mutants U-1, U-8, U-16, U-17, U-18, U-19, U-20, U-21, U-24, U-25, U-26, U-29, U-32, U-33, and *U-35,* were all apparently simple point mutations. The original cultures were phenotypically stable when subcultured serially. When mated to wild-type, they produced progeny identical to the original mutant. The factor responsible for the production of the phenotype segregated at meiosis proving that the variation was genic. *Mutant U-12* fell in this group except that the serial subcultures showed more variability.

Mutant U-1. Bead-fluffy. Mycelia with beads of water at the tips.

Mutant U-16. Stubby-fluffy. Stubby mycelia, peach colored colonial growth. This colonial mutant was epistatic to *fluffy.*

Mutant U-17. Ring-fluffy. Watery, ragged mycelium, brassy color. This gene was located close to spindle fiber on the *fluffy* chromosome.

Mutant U-18. Apricot-fluffy. Bunched, clusters of mycelium. Choppy, uneven growth.

Mutant U-19. Rainbow-fluffy. Globoid watery mycelium. Light yellow top to orange colored.

Mutant U-20. Billowy-fluffy. Billowy growth; medium height.

Mutant U-24. Clustered-fluffy. Even top, much branched hyphae.

Mutant U-25. Variegated-fluffy. Variegated brownish thick hyphae, scanty growth.

Mutant U-26. Bristly-fluffy. Bristly mycelium, irregular-fan-shaped habit.

Mutant U-32. Golden-fluffy. Large irregular golden globes.

Mutant U-33. White-fluffy. Scant growth at top with heavy white band at base of culture.

Mutant U-35. Slow-fluffy. Grew 48 hours later than standard *fluffy.*

A Progressive Mutation

Mutant U-8. Burnt-fluffy. This double mutant was unusual in showing greater vigor than pure *fluffy* alone. The single mutant *burnt* was more vigorous than wild-type, produced taller growth in the tube with more and richer colored conidia. It resembled wild-type except for its greater vigor. It was located on the *fluffy* chromosome about 23 units from the centromere. This ultra-violet mutant is the first progressive mutant we have discovered in *Neurospora.* No mutant even approaching it in vigor has occurred spontaneously or was obtained in the x-ray series.

A Reverse Mutation

Mutant U-21. Button-fluffy. The mutant *button* produced a small button-like colony, about six mm across (like *Penicillium,* see *X-16*). on the surface of the unslanted agar in a small (10 mm) tube. As the culture grew older, the small colony was raised from the surface of the agar and grew taller, attaining a height of about five mm, but without reaching the sides of the tube. Eight asci were analyzed, yielding 32 *button* cultures. In three of these 32 colonies, reverse mutations occurred and a spreading growth subsequently extended to the sides of the tube and grew up along the walls in typical exploratory *Neurospora* fashion. The other genetically identical twin ascospore from each of these three

LEGEND TO FIGURE 10—Continued

evident. When this was done it was discovered that Mutant U-24 (*B*) and U-32 (*D*) were conidial mutants, while Mutant U-19 (*C*) was non-conidial, and produced no conidia at any stage of growth. The photographs of the Mutants U-24 and U-32 show that no conidia were formed, indicating that the *fluffy* gene in the double mutant combination suppressed the formation of conidia as effectively as it did when alone. All the double mutants were non-conidial in spite of the fact that some of the pure mutants separated from *fluffy* by segregation produced conidia.

pairs developed the mutant-type colonial growth.

A Modifier of Fluffy

Mutant U-29. Sheen-fluffy. Pale, delicate sheen on *fluffy* growth. Mycelia with finger-shaped ends. When *sheen-fluffy* was mated to wild-type, only three kinds of phenotypes were recovered: 1. wild type, 2. *sheen-fluffy,* and 3. *fluffy.* This gene produced no phenotypic effect when alone, but was detected only as a modifier of *fluffy.*

A Semi-Lethal Mutation

Mutant U-9. Branching-fluffy. Much branched mycelium tends to be billowy. When mated to wild-type, eight apparently ripe spores were produced. When the spores of four asci were heat-treated, all eight spores germinated in each ascus and were transplanted to tubes. However, half of the spores from each ascus failed to produce cultures. The spores which grew apparently did not carry the mutant gene indicating that it was a semi-lethal which could not pass through the ascospore stage. When matings were made between the four viable spores remaining in the ascus, eight viable spores were produced in each ascus. thus eliminating the possibility that the lethal effect was due to an inversion.

A Quadruple Mutant

Mutant U-7. Bunch-fluffy. Mycelium tends to grow in bunches. Low growth in tube. Analysis of asci obtained by mating *U-7* by wild-type indicated that it was a quadruple mutant. Three mutations had been induced in the original *fluffy* spermatial nucleus and the segregation in the ascus indicated a tetra-hybrid ratio although the analysis was not sufficiently extended to clear up the problem completely.

Segregant *U-7a,* produced rich orange colored conidia which grew rather close to the agar.

Segregant *U-7b* was also a conidial form with tall aerial hyphae but few conidia in tight clusters.

Segregant *U-7c* was non-conidial.

A Heterokaryon

Mutant U-3. Broom-fluffy. Poor growth, short broom-shaped mycelia. This mutant was stable on subculture. Two kinds of asci were obtained when matings to wild-type were made. One type of ascus carried only the *fluffy* gene and its normal allel. The other was heterozygous for wild-type and a fluffy colonial mutant. The stability of the original culture indicates that the two nuclear components of the heterokaryon were well balanced.

Degenerate Phenotypes

Mutants U-4, U-5, U-10, U-11, U-13, U15, U-22, U-23, U-27, U-30, U-31, and *U-36* were degenerate mutants, producing little or no aerial mycelium. Many of these weak mutants proved to be fully fertile when mated to normal tester strains. These matings usually produced only *fluffy* and wild-type progeny; few or no cultures showing the original mutant gene were recovered. The single notable exception was *Mutant U-11.* The analysis of these ultra-violet induced degenerate phenotypes presents considerable difficulty. (*U-11* is obviously a single gene mutation in spite of the fact that it resembles the other eleven.) The progeny of *U-13* and *U-31* suggest that these variants might be classified as reversible gene mutations, but specific proof of their genic nature is not available. In view of Winge's[2] clear proof of the existence of cytoplasmic inheritance in yeasts, the lack of evidence concerning the genic nature of the ultra-violet induced degenerate phenotypes makes it advisable to withhold judgment. This also suggests that some of the unstable X-ray induced variants may be due to an effect on a non-genetic mechanism.

Mutant U-4

Mutant U-4 was a typical degenerate phenotype with poorly growing, straggly, browning mycelium, mostly beneath the surface, and a dark-brown substrate-color. Matings of the original spermatial culture with wild-type yielded four *fluffy* and four wild-type cultures from each of nine asci. In three other asci an insufficient number of viable cultures was obtained to complete the analysis. The original culture was planted on a plate of potato dextrose agar and hyphal tips were cut off from the advancing margin of growth and planted in potato dextrose tubes. Twenty-one of these hyphal tips produced cultures, all with the characteristic degenerate phenotypes, although two of the 21 produced a little more vigorous aerial growth, no complete reversions to standard *fluffy* were obtained.

Mutant U-5

The degenerate phenotype *Mutant U-5* reverted to *fluffy* on subculture. Ten asci were analyzed from matings of the original spermatial culture by wild-type and no characteristic degenerate phenotypes were recovered. The agar from the original tube, showing no aerial hyphae, was placed in the center of a potato dextrose plate and a few days later a fringe of slow growing hyphae emerged from the agar mass and spread over the plate. Tips of these hyphae were transferred to small tubes. When the tips were cut, the protoplasm emptied out of the tubes. This is unusual, for ordinarily when a hyphal tip of *Neurospora* is cut, the protoplasm empties out of only a small portion of the hypha near the point at which the cut is made, while the protoplasm in the remainder of the tube stays in place. In view of this, large masses of the hyphae were removed to ten transfer tubes, but no viable cultures were obtained.

Mutant U-10

Mutant U-10 was a typical degenerate phenotype which died on serial transfer, but the analysis of 22 asci did not result in the recovery of cultures resembling the original parent. Instead, each ascus contained 4 *fluffy* and 4 wild-type forms.

Mutant U-13

Mutant U-13 on subculturing died out like *Mutant U-10,* but a mating of the original spermatial culture by wild-type resulted in viable progeny. Six asci were analyzed and each was found to contain four *fluffy* and four wild-type mycelia. A month later, seven asci were analyzed from the same tube. The viability of the second batch of ascospores was rather low and a number of the cultures developed very slowly. These were observed under the microscope to resemble closely the typical growth habit of the degenerate phenotype. Six of these subsequently produced characteristic *fluffy* mycelia, while three developed into obvious mutants, differing from either *fluffy* or wild-type.

Mutant U-31

Mutant U-31 was a typical degenerate phenotype. Analysis of six asci from a cross with wild-type, resulted in the recovery of four wild-type and four *fluffy* ascospores from each ascus. A month later, 14 asci were dissected from the same tube. In 13 of the asci only four *fluffy* and four wild-type progeny were obtained. Eighty of the 104 ascospores produced germ tubes and when transferred to potato dextrose tubes, each one produced a culture. The 14th ascus is shown in the following tabulation.

1. Germinated and died.
2. Original mycelium degenerate phenotype, later produced a wild-type culture.
3. Germinated and died.
4. Germinated and died.
5. *Fluffy.*
6. *Fluffy.*
7. Failed to germinate.
8. Wild-type.

Degenerate Phenotypes Apparently Reverting to Wild-Type

Mutant U-15 died out when subcultured. When the original culture was planted on potato dextrose agar and 22 hyphal tips were selected, 15 of these yielded typical conidial wild-type cultures and seven failed to grow. On serial subculture, Mutant *U-22, U-27,* and *U-36,* similarly produced conidial wild-type cultures. In *U-22,* matings of the original spermatial culture with wild-type gave five

TABLE I.—Classification of Ultra-Violet Mutants

		Sub-culture	Remarks
Single gene mutation	U-1, U-8, U-12, U-16, U-17, U-18, U-19, U-20, U-21, U-24, U-25, U-26, U-32, U-33, U-35	Contant	
	(a) U-12	Highly variable	
	(b) U-16, U-19, U-21, epistatic to fluffy		
	(c) U-33, modifier of fluffy		
Single gene mutation	U-29, modifier of fluffy no effect on wild-type	Variable	———
Semi-lethal mutation	U-9	Constant	———
Quadruple mutant	U-7	Constant	———
Heterokaryon	U-3	Constant	———
Weak, reverting phenotype	U-14	First 3 sub-cultures weak, 4th reverted to normal fluffy	All progeny non-mutant, each ascus 4 fluffy, 4 wild-type
Degenerate phenotype	U-4, U-5, U-10, U-13, U-31	4, 5 reverted to fluffy, others died	All progeny non-mutant, each ascus 4 fluffy, 4 wild-type
Degenerate phenotype	U-15, U-23, U-30	Died	No matings made, cultures died
Degenerate phenotype	U-22	Reverting to wild-type?	All progeny non-mutated, 8 wild-type. Contaminated?
Degenerate phenotype	U-27, U-36	Reverting to wild-type?	No matings made.
Degenerate phenotype	U-11	Constant	Exceptional degenerate phenotype, ascospore progeny carrying degenerate gene
Probably not mutants	U-2, U-6, U-28, U-34	Classified as mutants because first cultures slightly different. All other transplants are standard fluffy. Progeny 4 fluffy, 4 wild-type per ascus.	

asci containing only wild-type ascospores.

It is difficult in a laboratory when large masses of conidia are handled regularly to interpret these four cases as reverse mutations because of the possibility of contamination. If they are reverse mutations, it would mean that the original mutation had occurred at the *fluffy* locus and this was not in the case in any of the other 40-odd mutants which had arisen in this work nor have we ever found a case of reverse mutation of *fluffy* in all the thousands of cultures of this stock which we have handled. Although conidial wild-type forms may possibly escape into the laboratory, the non-conidial forms even though they produce spermatia capable of acting as conidia never escape from the culture tubes.

Mutant U-11

Mutant U-11 was classified as a degenerate phenotype. It proved perfectly stable on subculturing and regularly produced sexual progeny identical to itself.

Discussion

Less than one percent of the ultra-violet treated spores survived treatment and about nine percent of the survivors were mutants. In the x-ray treatment about 50 percent of the spermatia survived and about one-fourth of the x-ray treated survivors were mutants. Considerably more than 80 percent of the controls germinated. The cultures used were different, but in the same pedigreed line.

It is not feasible to induce mutations in our material without causing a considerable number of deaths among the treated individuals and the problems of the genetic constitution of those individuals which fail to survive, complicates any attempt at comparison.

There are many other difficulties that attend any attempts at comparison of the mutations induced by ultra-violet and x-rays. A complete analysis requires data on the exact amount of the radiation absorbed by all the structures between the source and the nucleus. There is really no bio-physical basis on which comparable ultra-violet and x-rav dosages can be quantitatively established.

A classified list of the ultra-violet and x-ray mutants:

Type of mutation	Ultra-violet	X-rays
Single gene mutations	20	11
Single gene degenerates	12	1
Diminished fertility	0	9

One of the ultra-violet mutants grew better and showed greater vigor on potato dextrose agar than wild-type. This is the first progressive mutant we have encountered.

Genetic analysis indicates that the diminished fertility in the x-ray mutants was due to chromosomal rearrangement. There were no similar cases of diminshed fertility among the ultra-violet mutants.

The ultra-violet mutants contained a significant excess of the degenerate type of mutant.

Three of the induced mutants grew as colonies and in our experience with about 100 spontaneous mutants, we have never found a single colonial form.

Emmons and Hollander[1] performed experiments in which cultures originating from the single mononucleate spores of a dermatophyte were used. The single mononucleate spores from a fresh culture were treated with ultra-violet rays. This experiment removes the possibility that the variation may be due to the separation of a spontaneously produced heterokaryon. However, they were unable to determine if their induced variations were true mutations because the fungus they used had no sexual cycle. In their experiments, they classified all the cultures which reverted to the wild-type as *non-mutants*. A large, but unspecified number of these forms resembled the degenerate phenotypes which we have described. These were called "temporary changes" and distinguished from the "permanent variations" or mutations.

Summary

Ultra-violet treatment of the uninucleate spermatia of *Neurospora crassa* induced many stable simple gene mutations. None of the ultra-violet mutants showed the diminished fertility characteristic of chromosome inversion. Nearly half of the mutants were degenerate phenotypes which did not yield to genetical analysis.

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POPULATION GROWTH AND FERTILITY TRENDS IN THE UNITED STATES

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FROM 1790 to 1930 the growth of the population of the United States was indeed rapid. Increases of one-fourth to one-third were registered during each decade of the nineteenth century. After 1900 the rate of increase fell from about 21 per cent in the decade 1890-1900 to 16 per cent in the decade 1920-1930, but the absolute augment of population per decade remained high, reaching a maximum of about 17 millions in 1920-1930.

In contrast, the returns of the 1940 Census of Population show a ten-year rate of increase of only 7.2 per cent, the smallest ever recorded. This figure is less than half that recorded at any time since the First Census in 1790, and only one-third to one-fourth as large as that observed in any decade prior to 1910. The absolute increase between 1930 and 1940 amounted to some nine million persons, or only about half a million more than the augment registered between 1860 and 1870. It is thus apparent that the epoch of rapid growth is over, and that the pattern of population growth in the United States underwent a considerable change during the 1930's — a change which will have far-reaching effects on future population.

Estimates of the future population indicate not only that the country is approaching an epoch of stationary population, but that there is good reason to suspect that our population will begin to decline within forty or fifty years. Between 1940 and 1980 it is expected that the population will increase by some 20 millions. It will be recalled that in the decade 1920-1930, the absolute increase was 17 millions, or only three millions less in that one decade than the total anticipated increase in the next forty years.

It is estimated that the population will increase from the 1940 figure of 131,669,000 to about 140,561,000 in 1950, 147,000,000 in 1960, 151,000,000 in 1970, and 153,000,000 in 1980.[4] During this last decade the population will thus increase by only 1.2 per cent (as compared with 7.2 per cent between 1930 and 1940 and 16.1 per cent between 1920 and 1930). Soon after 1980, it is thought, the population will reach its peak and will then begin to decrease.

With this marked slackening of the Nation's population growth it becomes imperative that we study thoroughly the factors underlying this problem. Accordingly, let us separately examine the factors which cause population growth and decline. Populations increase through births and immigration, and decrease through deaths and emigration. Death rates in this country, we know, have been steadily decreasing and can be expected to decrease further. Emigration from this country has always been and will probably continue to be of negligible volume. Therefore, the slowing down of population growth cannot be attributed to these two factors; instead we must seek an explanation in the trends of the birth rate and of immigration.

In the past this Nation has received large numbers of immigrants from European countries. During some decades such immigration numbered into the millions; from 1930 to 1940, however, the number of immigrants practically balanced the number of emigrants, with the result that there was no population growth from this source. In the light of the present legislation regarding immi-

*The author wishes to express his appreciation to Mr. G. R. Shipman for his assistance in the preparation and editing of this manuscript.

gration it is highly unlikely that there will be any change in our laws to permit the unlimited immigration of Europeans.

It is thus apparent that the sharp decrease in future population growth will be entirely, or almost entirely, attributable to a decrease in fertility. It is known that our birth rate has been falling for some time, and it will probably continue to decrease in the future. Obviously, then, the Nation's future population growth will be intimately affected by the trends in fertility. In this paper we shall review some of these basic trends and relate them to the recent preliminary findings of the 1940 Census of Population.

Trends in Fertility

Historical trends in fertility. The birth rate in this country (however measured) has been decreasing probably ever since the beginning of the nineteenth century. Willcox,[5] writing in 1911, offered evidence that the birth rate (measured by the number of children under five years of age per 1,000 women aged 16-44) fell from an estimated 976 in 1800 and 1810 to 541 in 1900. Since 1900, this ratio has continued to decrease, reaching a low of 344 in 1940. Whelpton[3] calculated similar rates for the white population from 1800 to 1920. His results very closely paralleled Willcox's. As measured by the ratio of children to women it would thus appear that fertility had decreased by well over half —almost two-thirds—during the last 140 years. Lotka,[2] employing crude birth rates, has shown much the same trend for the period 1870 to date.

Net reproduction rates, 1930-1940. That this trend, noted above, has continued through the decade 1930-1940 is revealed by a preliminary analysis of the returns of the 1940 Census of Population. The net reproduction rate for the United States for the period 1935 through 1939, based on a preliminary tabulation of a five per cent cross-section of the 1940 census returns, was 96 as compared with 111 for the five years preceding the 1930 Census. In other words, if present birth and death rates remain unchanged, the population will eventually reach a point where it will decrease by 4 per cent per generation.

The census returns also showed that urban areas in every State had net reproduction rates below 100, whereas the rural areas of almost every State had rates above 100. Striking differences appear in the rates for the white and nonwhite populations and in the rates for the various regions and States. The rate for whites in this country as a whole was 94 as compared with 107 for nonwhites, and the rates for the three major regions were: South, 111; West, 95; and North, 87. Therefore, if present birth and death rates at the various age levels remain unchanged, the white population will eventually decline at a rate of about six per cent per generation, while the nonwhites will increase at a rate of about seven per cent per generation. Under the same conditions, the North and the West will decline at rates of 13 per cent and five per cent per generation respectively, while the South will increase at a rate of about 11 per cent per generation.

The net reproduction rate in urban* areas of the United States for the five-year period preceding the 1940 Census was 74, which potentially would bring about a decrease in urban population of 26 per cent per generation, if there were no net migration to urban areas. In contrast, the net reproduction rate for the rural-nonfarm areas was 114, and that for rural-farm areas 144. In the long run, therefore, the population in rural areas will reproduce at a rate well above the replacement level, although not sufficiently to offset the deficit in urban areas. (See accompanying table.)

*In general, urban population as defined by the Bureau of the Census, is that residing in cities and other incorporated places having 2,500 inhabitants or more, the remainder being classified as rural. The rural population is subdivided into the rural-farm population, which comprises all rural persons living on farms, without regard to occupation, and the rural-nonfarm population, which is made up of persons living in incorporated places having less than 2,500 inhabitants, in small unincorporated places, and in open country locations other than farms.

In the five-year period ending with the 1940 Census, rates for all urban-rural residence groups were substantially below those for the corresponding groups in the period 1925 through 1929. The decrease over the decade was greatest in the areas where the rates were already lowest; decreases of 16 and 14 per cent, respectively, were registered in the urban and rural-nonfarm areas in contrast with a decrease of only 9 per cent in the rural-farm areas.

The three major regions showed marked differences in rates, the rate for the South being the only one which exceeded the maintenance level of 100. The respective rates for the 1940 period were:

South	111
West	95
North	87

The lowest rates were reported for the large industrial Northern States of the New England and Middle Atlantic divisions and for the Pacific States. The highest rates were reported for the predominantly rural areas of the South and for the Mountain division.

The regional rates of the 1940 period represent substantial changes from those for 1930, all of which were above the replacement level:

South	127
North	103
West	101

During the decade net reproduction in the North and South decreased by 16 and 13 per cent, respectively, while in the West it decreased much less, about six per cent.

To a large extent the regional differences are explained by differences in urban-rural composition of the three regions. The South and West contain considerably larger proportions of the prolific rural population than does the North. The influence of differing urban-rural compositions in the three regions can be held constant by determining what the regional rates would have been if the population of each region had been distributed by type of residence in the same proportions as the United States population. When this recalculation is made, the standardized rates become:

South	101
West	99
North	95

The greatly reduced differences calculated on this basis represent those accounted for by factors other than regional differences in urban-rural composition.

For the entire United States the net reproduction rate for the white population in the five-year period ending in 1940 was substantially lower than that for nonwhites, 94 as compared with 107. The United States totals, however, are

TABLE I.—Net Reproduction Rates by Color and Urban-Rural Residence, for the United States, by Regions: 1940 and 1930.

(1940 data are estimates based on a preliminary tabulation of a 5% cross-section of the 1940 census returns)

Region and color	1940				1930			
	Total	Urban	Rural-nonfarm	Rural-farm	Total	Urban	Rural-nonfarm	Rural-farm
All classes								
United States	96	74	114	144	111	88	132	159
North	87	74	109	133	103	90	128	150
South	111	75	118	150	127	86	138	165
West	95	75	120	138	101	80	129	155
White								
United States	94	74	114	140	111	90	133	159
North	87	74	109	133	104	91	128	150
South	110	76	120	145	132	92	145	169
West	94	76	119	134	99	79	128	151
Nonwhite								
United States	107	74	114	160	110	75	119	156
North	83	79	[1]	[1]	87	82	[1]	[1]
South	113	71	112	160	115	71	116	153
West	119	[1]	[1]	[1]	157	[1]	[1]	[1]

[1] Rates not shown for those population groups which, in 1940, had fewer than 20,000 females under 5 years old.

greatly influenced by the heavy concentration of the nonwhite population in rural-farm areas where rates are highest. When the data are examined separately for each residence group we find that in urban areas the rates for whites and nonwhites differ only slightly and are identical for the United States urban totals (74). Similarly, rates for the rural-nonfarm totals are identical for both color groups (114). In the rural-farm areas, however, nonwhite rates exceeded those for whites in all of the seven States having sufficient population to permit the computation of rates for both color groups and for the United States total (160 for nonwhites and 140 for whites). Furthermore, the proportion of the nonwhite population living in rural-farm territory greatly exceeds the corresponding proportion for whites (33 per cent as compared with 22 per cent). This combination of maximum rates for nonwhites in rural-farm areas and the disproportionately large numbers of nonwhites living on farms is the major factor in determining the higher United States total rate for nonwhites.

If the United States rates for white and nonwhite were "standardized" to show what the rates would be if both of the color groups were distributed by residence areas in the same proportions as the total population, the recalculated rates would be:

Whites	97
Nonwhites	102

It is thus apparent that much, if not most, of the difference between the white and nonwhite net reproduction rates results from differential urban-rural distribution.

In summary we may note:

1) Under present fertility and mortality conditions the population of this Nation will eventually decline by four per cent per generation.

2) The rural areas are the only source of future population growth for both the white and nonwhite populations.

3) The nonwhites, because of their greater concentration in rural areas, have a higher net reproduction rate than the whites, 107 as compared with 94.

Population Growth in the Immediate Future

As a result of immigration and higher birth rates in the past we now have an unusually large proportion of persons in the age group 20 to 44—the reproductive years and also the years of relatively low mortality. Because of this age composition the observed average annual crude rate of natural increase during the period 1935-1939 was about six per 1,000—that is, the crude birth rate was about 17 per 1,000 population and the crude death rate about 11 per 1,000. Such an annual crude rate of natural increase, if it continued unchanged for a generation, would result in a population increase of some 18 per cent during a generation (assuming that a generation equals 30 years). In contrast, the net reproduction rate for the same five vears indicates a potential decrease of four per cent per generation.

Since there will be a large proportion of the population in the reproductive ages for many years (though this group will gradually decline in size), we shall continue to have a gradual growth in absolute population, even though the net reproduction indicates at the same time that the population is reproducing at a rate which over a long period will result in a decline.

Considerable increases in birth rates for the years 1940 and 1941 have been reported, but it seems probable that these may represent only temporary changes resulting from recent increases in marriages—an effect closely associated with improved economic conditions and threats of war. (These increases in the numbers of marriages and births will, of course, result in an immediate increase in population growth.) In view of the long-term trend, however, it seems unlikely that the net reproduction rate will again reach and maintain for any long period of time a size much above the replacement level.

Needed Research

These findings regarding the general picture for 1940 are important as far as they go. Their contribution to our

knowledge of the entire subject of differential fertility, however, is quite limited. On the basis of many studies already made we know that there are important differentials which an analysis of this type cannot hope to cover. We know that there are differences in fertility as between foreign-born and native white women, between the lower and upper economic classes, among groups at various levels of educational attainment, and among the different occupational groups. We also know that the entrance of women into the Nation's working force is an important factor affecting the fertility rate; other factors, such as religion and the rise in the divorce rate, may also be important. On the basis of our present knowledge, then, we can say that we are familiar with the broad outlines of the problems of differential fertility as of the present day.

Regarding some of the most important aspects of these problems, however, our knowledge is exceedingly limited. For example, we know almost nothing about trends in these differentials. Are the fertility rates of the various classes of the Nation tending to approach each other? Is there any evidence to suggest that rural fertility will soon fall below the needed replacement level? Among those groups in which fertility is now lowest, is there any evidence of a possible reversal in trends suggesting increased future fertility rates?

The next major set of problems about which we know almost nothing is the exact nature of the interrelationships of the different factors. For example, is educational level or economic status the more important in affecting the fertility rate? If the former, we may well believe that the increase in school attendance, particularly high school attendance, during the last decade will act as a force lowering fertility during the following decades. On the other hand, if educational attainment in itself is unimportant, but operates only through economic status, we may assume that the increase in school attendance in itself will have but little effect on future fertility rates.

It is evident, then, that our present knowledge of the factors associated with differential fertility, the influence of trends in fertility upon future population growth, and finally, the relationship of population growth to our economic structure are only imperfectly understood. Lorimer, Winston and Kiser[1] have recently surveyed this problem and summarized our present knowledge regarding it, and it is hoped that the returns of the 1940 Census of Population will yield some much-needed information.

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EUGENICS AND THE FAMILY

Panel Discussion of, at the Annual Conference of the American Eugenics Society, New York City, March 31, 1941

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MY experience is in public and consumer relations. It is regarding certain implications of these to a eugenic program that I will limit my remarks.

At the first New England Conference on Tomorrow's Children in the summer of 1940, Dr. Frank Lorimer ventured the prediction that questions concerning the family, population, and eugenics will become of major public interest during this decade. It seems to me that some advance signs of this can already be clearly seen.

Public interest will reflect itself in a growing avidity on the part of the press for news on these subjects — an avidity, which I scarcely need to tell you, is often directed rather more toward the sensational than toward the substantial aspects of the news. For some time to come, most people will know about eugenics what they read about it in the papers. First impressions, via press columns, will tend to create the basic prejudices, *pro* and *contra* eugenics, with which later, more substantial adult education will have to deal.

Although even the most careful efforts may prove disheartening, there is every reason to so conduct the dissemination of ideas via the press as to do the best possible job in moulding enlightened public opinion. In this respect, it may be pertinent to say that the time has probably gone by when it is worthwhile seeking headlines unless they say what you want them to say. At an early stage of this, as well as other ideological transitions, a certain amount of sensationalism is valuable in agitating the public mind, making it fluid, breaking down its rigidities of outlook. I would like to suggest that this time has now gone by for the eugenics, the population, the family relations movements. I would like to suggest that constant repetition of whatever fundamentals the experts are able to agree upon is more the order of the day. If existing and expanding public interest is to be crystallized into positive directives, for those who are beginning to look for answers, it means that what is "old stuff" to the experts must be repeated over and over again.

It also means that the experts must draw a clear line between private conference and public forum. In private conference there is room for the professors to ride their hobby horses and for the original and creative minds to luxuriate in esoteric speculation; these, indeed, are inescapable and valuable adjuncts to the advance of concepts and the joint formulation of minimum bases of agreement, blending random individual scientific or speculative inquiry. But so long as time and place is provided for purely individualistic, exploratory expression of opinion, there should be recognition of the dangers of using public conference for this purpose; there should be recognition of the practical consequences of allowing sensational statements to compete with sober statements for news attention from the same public platform; there should be recognition of the positive value of voluntary self-disciplined agreement among experts with different viewpoints, to whatever degree this is possible, and then the united front in expressing them, as a means of underscoring the accepted fundamentals.

Some care on the part of spokesmen of modern outlooks toward the family, population and eugenics may well result in the avoidance of distorted vulgarization and consequent social damage, which characterized the popularl-

zation of psychology in the post-war decade.

Furthermore, even these conservative pronouncements must be issued with the techniques of effective public and press relations in mind. A recent Conference in Connecticut demonstrates what can happen when this is not done —— the sensationalism, error and distortion in reportage that can so easily occur. If many John and Jane Does read such reports in the press, considerable damage and delay can result rather than clarification of eugenic ideas in the public mind.

I do not blame the reporters or the newspapers for such occurrences. Every speaker in these fields who addresses a public gathering should have a written manuscript. Those running the meeting should see that reporters have access to it. Conference planning committees should make full provisions for the press, which include space, briefs of manuscripts, access to original manuscripts, access to speakers, where possible, and access to one well-informed person designated as press contact.

In the future, however, education in the family, population and eugenics will depend less and less upon purely propagandistic channels for the distribution of ideas, and more and more upon effective integration of these outlooks with those of other educational and social movements, through constantly closer organizational contact and cooperative programs. It is in regard to this that I would suggest that considerable attention be given to the consumer movement as a natural, although still unenlightened ally.

Measures in nutrition, sanitation, housing, recreation, health, family services, and other environmental aids to eugenic population replacement are also measures which concern the large consumer movement in this country; the consumer movement has not, however, shaped or modified its program in the light of eugenic knowledge and principles. The eugenics movement can bring to the consumer movement broader concepts and clearer directives toward desirable historical evolution of the society; the consumer movement can offer the eugenics movement experience in rank and file adult education and social organization relating to the achievement of consumer measures, which often would need only slight revision to conform to measures recommended by students of family, population and eugenics.

Both movements being classless in character, will have in common one ultimate question of direction and policy for decision. Should they in attempting to modify an organized class-political-pressure-group society organized around the productive scheme, likewise politicalize their social aims and seek to achieve them by driving for incorporation of new bureaucratic functions and services into the political state? Or should they break sharply with this 75 year world drift and pursue a program of independent social construction through the technique of voluntary social and economic coopera tion? To my mind, the whole future of both movements will be determined by their answers to this fundamental question.

While I cannot say what the logical answer is as regards the eugenics movement, there can be no question but that the logical extension of consumer economic theory and consumer action leads to the beginning of independent social-economic action toward the creation of a cooperative system of production and distribution as the required form of social organization to utilize 20th century technology. Insofar as eugenic measures are consumer measures, I should think that this same would hold true. In my view, the politicalization of the two movements will lead them into the dead end of statism, in which the creative powers of all the progressive movements of the last century have been trapped and stultified.

It seems to me that achievements in creative social-economic construction via the technique of cooperation as in Nova Scotia are of no less significance to the eugenics movement than to the consumer movement. In our highly urbanized American society, pursuit of similar techniques will lead naturally

to the social unit plan of urban neighborhood organization, along cooperative lines.

Neither the Antigonish movement nor the social unit planners appear to have organized their programs in the clear light of eugenic needs, although limited eugenic consequences would be implicit in their efforts. If, however, the eugenics movement were to join in giving disciplined eugenic direction to the emerging, scientifically organized, urban social unit consumer cooperative movement in the United States, the achievements in social creation and eugenic historical evolution during the second half of the 20th century may be magnificent indeed.

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GENETICS FOR THE MORAL PHILOSOPHER

THIS volume* is a condensed presentation of modern genetic principles. In the introduction, the author points out the importance of a knowledge of genetics to biologists and non-biologists alike, including "le pedagogue, le moraliste, le theologien, le legislateur." The main reason for writing this elementary text-book was that present manuals are too technical for the use of amateurs. The importance of genetics in agriculture is pointed out.

On page four the author makes a statement which seems to the reviewer unfortunate in its implications as to the genetic position in regard to democracy:

> La genetique met en lumiere la sagesse de certaines lois de l'Eglise touchant le mariage et demontre l'inanite du principe fondamental des democraties qui veut tous les citoyens egaux par la naissance.
>
> Elle ne justifie pas pour cela les castes des civilizations autocratiques ou plutocratiques et reduit a neant la theorie de Jean-Jacques Rousseau: "L'homme nait bon, la societe le pervertit".†

While genetics teaches that men are born indeterminate, unpredictable, and highly variable, with many different qualitative and quantitative characteristics, the reader is left with the impression that genetics fails to support the theories underlying democracy, and that genetics leaves the scientist in a philosophical quandary. It is obvious that the real function of the democracies has been overlooked in Rousseau's statements. Since men are indeterminate, unpredictable, and highly variable, the ideal way is to allow the genetic unknowns to develop in an environment where the accepted ideal is an equal opportunity for all,—which is the keynote of democracy.

In nine chapters, the following headings are used as topics: monohybrids, di- and poly-hybrids, interaction of factors, quantitative characters and biometry, the chromosome basis of heredity, the inheritance of acquired characters and mutation, cytoplasmic heredity, and a short history of genetics. Problems are given at the end of each chapter, and the answers supplied at the end of the book. A glossary of genetic terms is included and a bibliography listing some outstanding works in the field. The material has been brought up to date, is well organized, and should be useful to students who are reading scientific French.

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**Notions Elementaires de Genetique*, 2e. edition, by JACQUES ROUSSEAU. Pp. 153. $0.60. Bulletin no. 2 du Jardin Botanique de Montreal. 1941.

†Translation: "Genetics throws light on the wisdom of certain laws of the church touching on marriage and demonstrates the emptiness of the fundamental principle of the democracies which wishes all citizens equal through birth.

"It does not justify on account of this, the castes of autocratic or plutocratic civilization, and reduces to nothing the theory of Jean-Jacques Rousseau: 'Man was born good, society perverts him'."

HELPING YOUNG AMERICA TO RESPONSIBLE PARENTHOOD

Through Social and Economic Aids*

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THERE are good reasons for welcoming the cessation of population growth in the United States. Our vaunted prosperity is based in large part on the low ratio of people to resources which characterizes new countries like the United States, Canada, Australia and New Zealand. We may be glad that this sound basis for material progress is not threatened here, as it is in Mexico and the Caribbean, by the indefinite continuance of rapid population increase. On the other hand, the prospect of a trend toward rapid decrease raises some very serious problems, especially in view of differences in reproduction among various segments of our population.

Our nation is now predominantly urban. Only 22 per cent of all gainful workers are now engaged in agriculture, forestry and fishing — in contrast to 69 per cent one hundred years ago. Our people are acquiring more advanced education; two-thirds of our youth are now enrolled in high schools. But those who go through high schools and live in cities do not reproduce themselves. The best index yet available for urban white women with high school education indicates that on the average they are having only 68 per cent of the number of children needed to supply an equal number of women in the next generation. This figure may be somewhat too low today, but there can be little doubt that the true figure ten years hence will be still lower. The reproductive equilibrium of our population today must now be attributed to the high fertility still characteristic of more isolated and less advantaged groups, notably families living in poor rural areas. These families more and more are adopting, and should adopt, birth control measures that will relieve them from the special burden of extremely large families which they are least able to support. To assure the future of the nation conditions must be created that will lead educated parents in the broad middle classes of American society to have moderately large families.

The American people, we may be sure, will repudiate any suggestion that population be maintained by a general suppression of the means of family limitation or by keeping part of the people in ignorance of methods already widely accepted among those with greater advantages. Nothing could be more repugnant to the ideal of democracy or more disastrous in its effects on our national life. It is equally obvious that, although changes in psychological attitudes are necessary, mere exhortation without economic and social changes would be futile. We must, therefore, give serious thought to the fundamental economic and social conditions which are essential to the maintenance of population on a voluntary basis, and specifically for an increase in the families of well equipped persons who participate actively in the main currents of economic and cultural progress in the United States. The measures adopted in the interest of population policy must also be of such a sort as to advance other lines of social progress. Fortunately, the broad outlines of a program which meets these requirements have already been worked out in

*Presented at the Fifteenth Annual Meeting American Eugenics Society, Savoy Plaza Hotel, New York City, March 31, 1941.

one small nation, Sweden — a nation which has led, and we hope can continue to lead, in the development of enlightened democracy. The task is much more difficult in such a vast and diverse nation as the United States, but there are many indications that thoughtful people in this country are beginning to recognize the problem and to prepare constructively to meet this challenge.

The development of an American population policy will show the necessity of large economic and social changes directed toward two distinct but related objectives: (1) We must create general conditions that support courage, high morale and confidence in the future. (2) We must develop specific measures which make it possible for young people to begin parenthood early and to have moderately large families without thereby jeopardizing the standards of living which they might otherwise attain. Progress along these lines must be worked out through sound social planning. If these plans are carefully developed they will be enthusiastically supported by the people of the United States and will provide a secure basis for American democracy.

Birth Rates as an Index of "Virility"

The *general* economic and social conditions for population maintenance are rather neglected by contemporary social scientists. This neglect may be a reaction to a false notion, still widely prevalent, that rapid natural increase denotes a happy people and that those whose "course is bound in shallows and in miseries" do not multiply. Extremely high birth rates are still cited in some quarters as a proof of virility, whereas they are in reality symptomatic either of low standards of living or of isolation from the main currents of contemporary culture. To refute this notion one need only point to Tobacco Road, Puerto Rico, or southern Italy as contrasted with northern Italy. On the other hand, in a population that has achieved voluntary parenthood, conditions that create widespread frustration and anxiety depress fertility below the level that might otherwise prevail. The fact that during the thirties Austria had the lowest birth rate in the world is significant in this connection. One may also point to sharp drops in birth rates in Europe and America after the onset of the depression, and to the drop in the birth rate of Sweden during the last war and the present war. The absence of any such trend in the United States today may indicate the absence of any widespread personal anxiety about the war, or may possibly be influenced by the special conditions of the draft. We may also note that while birth rates of college graduates are generally low, several studies show that within this group the largest families are found among those who have greatest economic security. Specific measures directed toward the voluntary maintenance of a people with high standards of living cannot be expected to have much effect in the face of recurrent threats of war, violent upswings and depressions in economic activity, or widespread anxiety. This assumption carries certain clear imperatives.

I. We must build a world order that provides security against war. From the standpoint of population policy this is a double imperative. War destroys lives and prevents births; even the imminent threat of war cuts births. At the same time, obsession with preparations for war throws false emphasis on sheer numbers, without regard to population quality or other social objectives. This false emphasis leads to the adoption of measures against family limitation as in Germany, France, and the Soviet Union, and even in nations already suffering from acute over-population like Italy and Japan. Even in China, a noted sociologist who formerly advocated limitation of population has recently urged the desirability of continued population increase for military reasons. This reasoning may be fallacious, even from the military standpoint, but it represents a natural, almost universal reaction. Sound population policy and eugenics can only ad-

vance in a world that is free from the menace of recurrent wars.

II. The promotion of responsible parenthood is perhaps equally dependent on our mastery of the forces which today make for the recurrence of false booms and devastating depressions. It is apparent that the automatic controls which are assumed in classical theory to regulate economic activity do not, under modern conditions, provide this stability. Public measures must be developed to meet this need, and the economic activities of government must be established on a sound financial basis. This is all the more necessary because many important measures directly affecting the status of parents and children will involve large public undertakings. These measures must therefore be based on scientific studies, integrated with other economic and social objectives, and developed experimentally on a sound economic basis.

III. Physical risks were much greater in primitive life. But risks that make for anxiety and caution in family affairs, worries about business failure, unemployment and loss of personal status, are accentuated in our society. Competition is an essential element in the structure of any advanced society—but there are many kinds and degrees of competition. American economic life has tended to exalt, as a cultural correlate, "the bitch goddess Success". A program promoting responsible parenthood can only be effective in an order which provides a larger measure of security and throws greater emphasis on community values.

Financing the Family

Population maintenance requires a high frequency of moderately large families — families with four, five and six children. This, of course, would not be the case if all married couples had two or three children. But many childless and one-child families are involuntarily so limited. And many others are restrained by personal reasons that cannot be lightly brushed aside. Uniformity is neither possible nor desirable. A drive toward enforced uniformity would be incompatible with the genius of democracy. Our aim must rather be to reinforce the natural motivations to full parenthood, and to make it possible for those who want large families to have them without thereby facing severe handicaps for themselves and their children. There is no reason for penalizing bachelors, spinsters, or childless couples. But, on the other hand, there is no good reason for granting them special economic rewards, which our society unwittingly does.

Consider the actual situation of a young married couple in the United States today. They are now, in accordance with American tradition, on their own resources. The young husband seeks a position in line with his interests and training. If he succeeds in this hazardous quest, he may gladly accept a position that holds fair promise for the future at small initial pay. He may want to continue his studies, or be burdened with school debts. His wife may decide to continue or to seek gainful employment. Data from the Consumer Purchases Study on native white urban wives under 40 years of age, with husband's income between $1,000 and $1,500, are pertinent here. In this class, 22 to 32 per cent of the childless wives report earnings — the percentage at the same income levels varying in different occupational groups, with the highest percentage in the professional group. But, under present conditions, such contribution to family income is difficult and is often deemed undesirable for the woman with children. Accordingly, for the same economic class, and for wives in the same age classes, only four to eight per cent of the wives with children report earnings, with the low figure now found in the professional group. There are few opportunities in our society for part-time employment for mothers, and almost no special provisions for maternity leave. The young woman who drops employment to have a child knows that she may find it very difficult to get an equally satisfactory

position sometime in the future. The urgency to postpone conception is, therefore, very great; and the same urgency may lead to repeated postponements over a long period. The economic character of this urgency is shown by the fact that as the husband's income advances the proportion of wives who report earnings drops sharply. For example, among childless wives in the professional group, the proportion of gainful workers drops from 33 per cent to 13 per cent, as husband's income rises from under $1,500 to over $2,500. Moreover, as husband's income rises, it becomes easier for the employed woman to make special provisions for the care of her children, though the proportion of wives in the higher income groups who choose to combine motherhood and gainful employment is still small. The effect of children on the income side of the family budget is therefore very important; but this is only part of the picture.

As children come, expenses mount—or rather, we should say, needs mount, for obviously at a given income level expenses cannot rise except by cutting savings or by going in debt. Data from the Consumer Purchases Study show the way in which families in given income groups trim their expenditures to fit family size. The couples with more children do not, in general spend more for rent. They cannot afford to, except at very high income levels. So they stay in more crowded quarters, or get a larger apartment in a cheaper neighborhood. The couples with children cannot afford more for medical service or for recreation and miscellaneous items than childless families with the same incomes ordinarily spend for these things. They must therefore lower their standards at many vital points. They definitely cut down on expenditures for household equipment and for transportation. The one thing for which families with children spend more than childless families with similar incomes is food. The standardized proportion of total outlay going for food rises, for one typical urban sample, from 31.1 per cent for childless couples to 38.6 per cent for couples with three or four children — but even so the family with children must get along on a more restricted diet. The standardized expenditure per meal per food-cost-unit drops in the same sample, from 24 cents for the childless family to 14 cents for the family of mother, father, and three or four children. Apparently, the family with three or four children would need about twice the income of the childless family to maintain the same nutritional level without devoting a larger proportion of total expenditure to food. It is not surprising, therefore, that in spite of drastic economies the balance between income and expenditure is more precarious for the family with children.

Contemporary society places young couples in a position where they must severely limit the impulse to reproduce or face a sharp reduction in levels of living in matters which are considered vital in our culture. Only a few specially privileged couples can escape this dilemma. For this reason there is a deficit of births in families which plan their affairs with a high sense of responsibility. This condition menaces the foundations of our national life. The situation is one that calls for searching analysis, and a constructive public policy.

Changing the Patterns

Some of the changes needed can be effected through institutional adjustments, legal measures, and patterns of living that do not involve any increase of public expenditure. Regulations protecting the employment status of mothers, provisions for maternity leave with pay, and the development of special opportunities for mothers who want part-time gainful employment may be suggested in this connection. For example, preference might be given in teaching appointments to women with children, along with a division of the teaching load so as to reduce hours of service and strain on individual teachers. This would require a changed public attitude and the exercise of considerable imagination by school administrators —

but it might have great psychological value for the children, as well as affording a major field of activity compatible with maternity. Similar developments would be possible in many other fields — under the leadership of an imaginative N. M. A. (National Mothers' Administration). At the same time, the development of non-commercial opportunities for social contribution, education and recreation by women — which at present are viewed with scorn or amusement in some enlightened quarters — would seem to be definitely important and worthwhile. Discussion about the employment of married women is highly charged with emotion, and prejudiced by traditional ideas about male supremacy and the fallacious theory that the presence of women in the labor market necessarily reduces employment opportunities for men. But, at best, it is a difficult problem. The solution may be worked out through a double formula, which I offer with great humility.

I. Increase opportunities for gainful employment compatible with motherhood.

II. Develop measures which will relax some of the pressures which now tend to force married women to seek gainful employment — both as regards the economic pressure, through measures giving families greater economic security apart from the wife's earnings, and as regards institutional and social pressures through emphasis on alternative ways of obviating the association, which unfortunately is not wholly fictitious, between home-making and intellectual stagnation. Here again we should avoid compulsion and uniformity. Different individuals will solve the same problem in different ways, but we must establish conditions that offer solutions consistent both with individual interests and the needs of society.

Other constructive measures are possible which do not involve large public undertakings, but such undertakings will necessarily constitute a major feature of an adequate population policy. We have vastly extended social services in the United States during the last ten years. But this advance has been in large measure haphazard, necessarily oriented at many points to immediate needs and political exigencies. It has not been logically directed toward establishing a firm basis for stable economic progress. And it has not touched some of the most vital needs. Many phases of our whole social program might well be reoriented with specific reference to the needs of parents and children. This would mean both enlargement and redirection.

The development of an adequate social program on a sound, financial basis will require large increase in tax rates, especially in the middle income brackets. As this takes place, a substantial portion, e. g. one-fourth of the tax otherwise payable, should be cancelled for each dependent child — up to the income levels at which each additional child does not substantially reduce the level of family living. A large portion of the public revenue yielded by increased levies might be specifically directed to supplying goods and services needed by mothers and children.

The provision of goods and services has two distinct advantages from the standpoint of eugenics and public welfare over the alternative scheme of cash payments to mothers or family allowances. In the first place, such provisions tend to equalize the situation of families with varying numbers of children at each economic level, whereas a fixed payment in cash, proportional to average wages in the community, may afford a positive incentive to childbearing at some economic levels and none at all at others. The subsidization of special goods and services needed by children can never make childbearing profitable at any economic level, but it can provide real aid at all levels. In the second place, such a procedure directs society's contribution to child nurture specifically to vital needs, such as nutrition, health and education.

Public provisions for mothers and children should, so far as possible, be completely divorced from any sort of means test, as in the case of public education in the United States today—

by exactly the same logic that led our forebears to take such a radical step in this limited field. For example, an extension of the school lunch program to all children would be one concrete expression of a new public responsibility for the nurture of children. It would bring about a real increase in food consumption in the United States, and raise the nutritional level of the nation. At the same time, it would be one definite step, though not a very long step, toward equalizing the level of living of families of various sizes. New provisions for medical service might also be specifically directed to maternity care and child health. Other specific measures along similar lines are discussed in the growing literature on this important problem.

One concrete suggestion may have special pertinence at this time. All those who look ahead are giving anxious thought to the time when our vast armament program will be curtailed, and when the men drawn into military service will be discharged. Our energies must then be directed into new channels. There will be a great need abroad for materials to be used in reconstruction work. America must be prepared to make a positive contribution to this tremendous need. This contribution may have to be much greater in the long run than our immediate contribution to military operations, but it will be spread over a much longer period. The released energies of our people must in large part be directed toward meeting our own needs. After the first world war, residential construction provided a great field for investment and labor. But the unguided building boom then over-shot the market demand and the resultant decline which became precipitous in 1928 was a major factor in bringing about the depression. We shall again have a large need for new homes when this nightmare is ended. We now have a subsidized public housing program directed toward meeting the needs of one segment of the population which has been rather arbitrarily selected for these benefits — as having sufficient income to meet the required payments, but not such high incomes as to make their subsidization politically offensive.

Public housing offers an appropriate field for large scale enterprise in the post-war period, but it should be developed on a logical basis. Labor costs should be reduced through provision of fair payments on a yearly basis. If the old craft unions will not cooperate on this basis, we should turn to new industrial unions. Economies must be sought in design and in the purchases of materials. But above all the whole program, in so far as subsidy is provided, should be directed to the particular needs of a group for which special subsidy is socially justified. It might most appropriately be directed to meeting the housing and recreational needs of families with several children. In planning the whole program, we might well follow the Swedish system in which the whole subsidy is applied directly to the reduction of rentals in proportion to the number of children in the family.

Community centers, playgrounds, and nursery school facilities should be provided without expense to individual families.

These suggestions may at least serve to illustrate the basic principles on which we must proceed — if the public really becomes convinced that the future of the nation depends on measures which encourage responsible parenthood, and tackles the problem with energy and in democratic fashion. We must remove the gross economic handicaps which are now attached to parenthood. We must do this through measures which will promote the immediate physical and spiritual wellbeing of individuals. And the whole program should be developed on a sound financial basis, so that it will contribute to general economic stability and progress. Finally, such concrete expression of the nation's interest in the family and child life will provide the only sound basis for the development of new and more creative psychological attitudes toward children and the family.

WHY TWO CHILDREN -- OR SIX?

A Study of the Social and Psychological Factors Affecting the Fertility of Protestant Couples

THERE are huge areas of for-granteds in any discussion of human reproductive patterns. Since this will continue to be so for a long time, the basic reasons for having children or not having them are not easy to arrive at. Even the approaches which might be used are mainly still unworked. The rather ponderous Mother Goose of the questionnaire method can stalk milady in her chamber and can add considerably to existing funds of useful information. It is curious considering the amount of talk there has been about birth rates that until just recently no adequate attempt has been made to apply the questionnaire and interview method to a sample of the population.

A committee on social and psychological factors affecting human fertility was appointed some months ago by the Population Association of America. This committee, consisting of ten experts, has done a careful job of surveying the ground and in completing plans actually to tackle a sector of the population extensively enough and in detail enough to give a reliable cross section of the beliefs, urges, and pressures (economic and otherwise) which affect this important matter. The following excerpts from the preliminary report of this committee are of special interest to eugenists:

The primary purpose of the study may be summarized as follows: to ascertain (a) the extent to which the actual number of children which Protestant couples have is larger or smaller than the number they want, (b) how these couples are influenced by various social and psychological factors in deciding upon the number of children they want, and (c) how the size of their families would be affected by various measures which might be included in a national population program aimed at checking the decline in birth rate and improving the quality of the population.

At the present time little exact information is available regarding the extent or effectiveness of contraceptive practices among married couples in our population. Several studies have been made of selected groups, for example of wives who have attended birth control clinics, but the proposed study will be one of the first to deal with a large cross section of Protestant couples. For fertile couples it is designed to show the number of conceptions which (a) were planned i.e. contraceptive practices were discontinued because pregnancy was desired, (b) occurred when contraceptive practices were discontinued because of other reasons, (c) occurred in spite of preventive practices, and (d) occurred to couples who never practiced contraception. For childless couples the attempt will be made to distinguish between those who are childless from choice and those who are sterile, and to ascertain from the latter the reasons for this sterility. This type of information is essential for judging the changes in size of family which may come about through the more effective practice of contraception, and through better diagnosis and treatment of sterility and low fecundity.

Information regarding the reasons why couples want 1, 2, or some other number of children is even less adequate than that regarding the above topics in fact, until a recent study of army aviators (by Flanagan) it was almost non-existant. The proposed study should indicate the relative importance of a variety of factors, among them (1) the cost of rearing and educating children, (2) the desire for a higher standard of living, (3) the feeling as to the security of future employment and income, (4) the socio-economic and cultural level of the family, (5) the difficulty of obtaining adequate housing for larger families, (6) the liking for children, (7) the extent to which children are thought to interfere with personal freedom, which depends in part on the availability of household help, (8) the family background of the husband and wife, (9) the pattern of the social group to which the couple belongs, (10) the extent to which the husband and wife are traditionally minded, (11) the religious interest of the couple, (12) the extent to which the husband or wife feel personally inadequate, (13) the extent to which the husband and wife obtain ego-satisfaction from children, (14) the marital adjustment of the couple, and (15) the health of husband and wife, and of the children they already have had. Information regarding the extent to which each of the above factors affects the number of children desired is basic to the development of a sound program aimed at exercising social influence on the size of the family.

In evaluating the above factors an attempt will be made to ascertain how their influence would be modified by certain proposals which might be included in a program designed to check the decline in birth rates and size of family. Among the proposals already advanced

here or in Europe are (1) relieving parents of more of the cost of raising children, especially the cost of medical and dental care, and higher education, (2) providing adequate housing for families with several children at rents within their means, (3) opening nursery schools so as to reduce the extent to which children interfere with their mother's freedom, and (4) paying a so-called "mother's wage", based on the number of children.

* * *

During the last two years a group of populationists and psychologists has been working on plans for carrying out the study described above. Schedule questions and interviewing procedures have been tested, and plans laid for the construction of indexes, and the analysis of results. As a result of this experience the following recommendations have been made regarding methodology.

(1) Since the present study cannot be large enough to include a representative sample of all the married couples in the population, it should center on a group which (a) is not reluctant to cooperate in the study because of religious convictions, (b) has faced for several years in the past and will face for some time in the future the problem of deciding how many children to have, (c) has had sufficient education to be able to fill out the questionnaires, (d) contains families of all sizes—from no children to several children, and (e) is fairly uniform as to race, nativity, age, year married, and urban residence, so that the analysis need give only minor attention to these matters and can be focused on motivations. More specifically, the study should be confined to native white couples married in 1927 to 1929, the husband under 40 and the wife under 30 at marriage, neither spouse married more than once, neither spouse Catholic or Jewish, both spouses having completed elementary school, and having lived in a city of 25,000 or over most of the time since marriage. Native white urban couples who finished the eighth grade are recommended in part because of the indications that their fertility pattern is being approached more and more closely by the fertility pattern of other groups in the nation's population.

(2) The addresses of couples meeting the foregoing requirements should be obtained through a city-wide house to house canvass, using a short and simple schedule. * * *

(3) The wife in each eligible couple should be visited by a skilled interviewer with adequate training in sociology and psychology, who will ask the questions on schedule "A". This schedule is designed (a) to ascertain which couples believe they are sterile (i.e. cannot have a child) and the reasons for this belief, and (b) to interest fecund (non-sterile) couples in cooperating further in the study. The interviewer will attempt to arrange a second appointment with fecund couples, at which schedule "B" or "Bb" will be filled out by the wife and "C" or "Cb" by the husband, each working independently of the other. (Schedules "B" and "C" will be used by couples with children, "Bb" and "Cb" by childless couples.) Most of the 200 questions on schedules "B", "Bb", "C", and "Cb" will be answered by the respondent checking the appropriate category, only the "oral" section being filled out by the interviewer. Each husband and wife will be paid $1.00 for completing the schedule. An appointment will then be made for a third interview with each wife, at which schedule "D" will be filled out by the interviewer. This schedule deals chiefly with the history of pregnancies and of contraceptive practices, but usually causes no difficulty because of the rapport established during the preceding interviews. Field trials in two cities have shown that only a small proportion of couples meeting the requirements outlined above will refuse to cooperate in the study, hence that the couples from whom schedules "A", "B" or "Bb", "C" or "Cb", and "D" are obtained should be highly typical of the universe to which they belong. Certain measures of a typicalness will be available from Schedule 1 which is filled out for all couples.

It is proposed to extract by appropriate statistical procedure the maximum of value from the questionnaire responses. These data are to be put on punch cards so they can be utilized to the full. The preliminary report suggests that Indianapolis has great advantages for such a study. It is proposed to carry it out during the summer and fall of the current year. The report of the committee on the findings of this pioneer venture should be a document of great value in developing a rational, effective and democratic population policy.

✦

Eugenics More Important

It will be unfortunate if questions of national defense and other problems arising from the present World War are allowed to crowd out entirely our efforts toward safeguarding the quality of our future population.

In reality, such efforts are doubly important at the present time, since war has long been recognized as a highly dysgenic process, levying its heaviest toll upon the best elements — physically and mentally — of the population of every nation. The present world crisis ought by rights to stimulate rather than to retard eugenic efforts.

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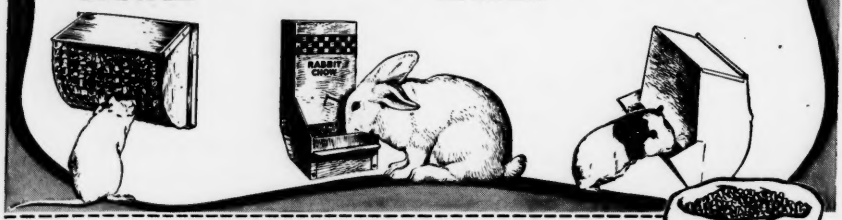

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